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Health and Society in Southeast Asia: The Transition from the Late Bronze Age to Iron Age.

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Abstract

Bioarchaeological studies incorporate components of bioanthropological and archaeological research. Alone each discipline presents valuable information, but when these disparate methods are used in combination to examine past societies, a holistic interpretation can result.

The purpose of this study is to develop a methodology that quantifies the overall health of individuals based on skeletal remains found in archaeological contexts. The Southeast Asian Health Index was inspired by the Western Hemisphere Health Index. The challenge in devising a health index for Southeast Asian skeletal remains from archaeological contexts is multifaceted. The index must be relevant at an individual level, easily reproduced by any user and include health attributes that are collected as standard from skeletal remains.

In this thesis, the Southeast Asian Health Index is developed and forms the basis of a series of bioarchaeological analyses. The index comprises the following attributes; age at death, dental health (alveolar bone health, caries and ante-mortem tooth loss), trauma, growth (enamel hypoplasia and long bone length), degenerative joint disease, childhood cranial and orbital lesions, and other pathological conditions. The structure of the health index enables comparison of individual health attributes as well as overall community health.

As a way to test this index, the transition period from the Late Bronze Age to Early Iron Age in northeast Thailand was investigated using health and social indicators. The two sites examined were Noen U-Loke and Ban Non Wat. The health of individuals within each time period, Mid Bronze Age, Late Bronze Age, Early Iron Age, and Mid Iron Age, were compared with societal indicators, seen in burial treatment.

Five hypotheses were tested in this study based on the results of the Southeast Asian Health Index and individual burial treatments. Two hypotheses are based solely on the Southeast Asian Health Index.

Firstly, it is hypothesised that the health of the people of Ban Non Wat and Noen U-Loke improved from the Late Bronze Age to Iron Age. It was found that overall health improved through time, but with complexity. This complexity was evident in the testing of the second hypothesis. In addition, patterns regarding individual health attributes could be identified. For example, this included an improvement in male dental health over time, whereas female dental health remained static.

The second hypothesis stated that health differentiation could be seen between archaeological sites in the same region. The context of the settlement influences the health of the village. In

this study, the newly established village of Noen U-Loke, in the Early Iron Age, showed a distinct difference to the well established village of Ban Non Wat.

Based on relationships between the Southeast Asian Health Index and burial treatments, two further hypotheses were tested.

The third hypothesis asserts that there is a correlation between burial treatment and health. A number of correlations between health and burial treatment were identified. These suggest that females buried with ornaments had poorer health, as did males with animal bones. It is postulated that these burial goods may be medical aides or amulets for the afterlife.

The fourth hypothesis tests the assertion that a correlation between health and burial treatment reflects social identity. It was identified that when health data are used in combination with burial treatment data, social identity was more reasonably distinguished than by using burial goods alone. The combination of health data with burial treatment enabled additional context, which ultimately altered interpretations of social identity based solely on burial goods. In one case, the interpretation of occupation suggested by the burial goods was refuted by the health data.

The final and fifth hypothesis relates to burial treatment and tests if society became more stratified from Late Bronze Age to Iron Age. Based on the sample, no evidence of stratified society could be identified.

Overall, it was found that the Southeast Asian Health Index provides a sound method of identifying relative health for individuals, groups and populations through time. Used in combination with archaeological contextual information it can provide multidisciplinary interpretations. The use of burial treatment data, rather than estimations of wealth to identify social identity, is distinctively different to previous studies. This study provides a unique bioarchaeological methodology, combining health and social status, to produce additional interpretations.

Glossary

BP	Before Present (1950 AD) – a measurement of uncalibrated radiocarbon years, counted from 1950 AD (CE).
Bronze Age	Generic technological classification based on the presence of copper alloys found in archaeological contexts. In the Khorat Plateau, Thailand dates approximately 3,000 to 2,400 BP.
DNA	Deoxyribonucleic acid.
Holocene	Environmental classification. Dates from 11,550 BP to present
Iron Age	Generic technological classification based on the presence of iron objects. Dates from 2400 to 1350 BP on the Khorat Plateau in Thailand.
Neolithic	Generally a lithic technology classification but has other connotations, including ceramics and agriculture. Its use in Southeast Asia is debatable, but the period dates from approximately 6,500 to 3,000 BP.
Palaeolithic	Lithic technology classification. Predates the Neolithic. In Southeast Asia dates from approximately 45,000 to 6,500 BP.
Pleistocene	Environmental classification. Dates from 1.81 million BP to 11,550 BP.

Abbreviations

BA	Bronze Age
BNW	Ban Non Wat
EH	Enamel Hypoplasia
EI	Early Iron Age
IA	Iron Age
LB	Late Bronze Age
MI	Mid Iron Age
MNI	Minimum Number of Individuals
NUL	Noen U-Loke
QALY	Quality Adjusted Life Years
SEAHI	Southeast Asian Health Index
WHHI	Western Hemisphere Health Index

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1 INTRODUCTION

1.1 A holistic approach

No person can live in absolute seclusion. From birth, we rely on others for care and protection, food and materials for shelter, and we also innately rely on social interaction for survival (Argyle, 1969). The complexity of human life and society is extremely intricate. Each person has a different life experience, whether it is as a result of their social background, location of their home, time period, level of education or illnesses over a lifetime. If the lives of humans over the millennia are complex, then the approaches used to aid understanding of past populations, needless to say, must also be complex. Whilst archaeological research engages multidimensional factors, probably due to the nature of academic research, some bioanthropological research can be regarded as a study in isolation. In those studies, one aspect is intensely examined and researchers focus on systematically perfecting one analytical technique at a time. Bioanthropologists, at times, can only examine a sum of the parts, but many challenge that approach and apply holistic methods.

Bioarchaeological studies challenge researchers to move beyond the interpretations contributed by bioanthropology and incorporate a multitude of facets found in archaeological research. Archaeological data provides indicators of social identity. Bioarchaeology can be described as coalescing disparate methods to interpret past societies. Early bioarchaeological studies used limited archaeological data or skeletal data, but as with most disciplines, methodologies have been modified and improved upon. As a result, interpretations that are more significant can be made.

New developments in bioanthropology have furthered the holistic nature of the bioarchaelogy discipline, but the process for identifying the overall health of an individual has not been adequately established. For example, examining dental, joint health and pathological markers on bone can all provide a distinctly separate narratives of a person based on each of those individual health indicators. Each health indicator can be then compared with each social identity indicator. The question remains as to how to combine all of these health indicators so that they can provide a holistic view of the health of an individual. By utilising a suite of bioarchaeological techniques and devising a method that provides a comparable index that is able relatively assess the health of one person against another, researchers can provide a multidimensional analysis of past populations. From the individual, data can then be manipulated to provide a view of the population. The methodology presented in this thesis is holistic and multidimensional. It utilises current accepted bioanthropological techniques for determining health from skeletons, combines them to identify overall health using a relative scoring method, and then evaluates health with contextual data.

The interdisciplinary approach in this thesis combines two innovative methods. The first is the creation of a health index (Southeast Asian Health Index) that focuses on the overall health of an individual. Each individual in a sample can be assessed based on relative scoring. This method ensures that the overall lifetime health of individuals, and consequently populations, are relatively comparable. This type of assessment has not been used on any Asian samples previously. A similar method, the Western Hemisphere Health Index (WHHI), has been used at a population level on non-Asian samples (Steckel et al., 2002b). However, the WHHI, in its current format, cannot be used on Asian skeletal samples, nor can it be used at the individual level, which is imperative to the study of past people. In addition, other reasons why the WHHI cannot be used in Southeast Asia include the use of health assumptions and problematic life-expectancy models, and in addition, the formulae for the calculation of the WHHI has not been specified, and therefore cannot be replicated by individual researchers. The health index presented in this thesis can evaluate the health of an individual and when individuals are combined, population and sub-group health can be assessed. It is an important analytical tool for Asian, and more specifically Southeast Asian, skeletal remains found in archaeological contexts. Equally important is that its use is not restricted solely to Asian samples and it can be used with any skeletal samples any where in the world. It can provide a method to rank any population, not just Asian or European, at all levels and groupings, including between individuals, which the WHHI lacks. Most importantly it provides a unique comparative tool. Where, previously, researchers could only surmise unhealthy populations and descriptively compare them, the Southeast Asian Health Index (SEAHI) provides a directly relatable assessment methodology.

The second method relates to how the archaeological context is used to determine social identity in each individual burial. Customarily, many bioarchaeological researchers examine whether or not aspects of the social identity of an individual had any impact on their health. Burial goods are scrutinized, and the status of a person is based on a wealth assessment, such as poor, rich, worker, or elite. The health of an individual or group is based on one or many factors and is then compared to their categorized wealth status. This method can be deceptive. In prehistoric sites, the wealth status of any individual or group is difficult to determine. The correlation between the burial goods in a grave and the actual wealth that individual had in life may not be accurate. We cannot assume that the modern day concept of wealth was relevant to the prehistoric people that we are studying. As a result, the information that can be gathered from burials may need to be examined differently. In this thesis, a variety of contextual data will be examined, not to determine wealth, but to identify social identity. Social identity can include many aspects of a person, and may include wealth, work roles, gender, as well as perception of self. This method is an attempt to move away from the more traditional view of burial offerings as a symbol of wealth and ascertains if a social identity can be distinguished.

To provide a true bioarchaeological, and therefore a holistic, analysis, the two methodologies are used to discover any patterns or characteristics that can be seen that relate to both the health of an individual or groups and the archaeological context, or burial goods. Skeletal health markers may assist in the understanding of the social identity of an individual in the same way that the burial goods found with that individual can. The combination of these two types of evidence, burial goods and skeletal data, has the potential to present a compelling interpretation of an individual. There can be many factors and contexts to examine, but it can also illustrate how health can assist in a social identity analysis.

1.2 The purpose of the study

The main purpose of this study is twofold: to devise a methodology to quantify the overall health of an individual based on skeletal remains from Southeast Asia; and, using this methodology, to investigate the transition period from the Late Bronze Age to Early Iron Age on mainland Southeast Asia, specifically northeast Thailand, dating from approximately 2700 to 1500 BP. In order to do this in a meaningful way, an interdisciplinary, bioarchaeological study is required. By assessing the health of individuals within each time period (Mid Bronze Age, Late Bronze Age, Early Iron Age, and Mid Iron Age) and comparing this with the indicators of society, seen in burial goods, a fuller understanding of each period is gained.

As there are a number of areas to be examined, this thesis has been divided into major chapters. Chapter 1 provides an overview of the archaeology and bioanthropology of northeast Thailand and related neighbouring areas. This includes sociocultural organisation, the procession of change in the archaeological evidence from the Palaeolithic to the Iron Age, as well as the analyses of health status at these two sites. The sites that form the basis of this thesis, Ban Non Wat and Noen U-Loke are discussed in more detail as well as the transition from the Bronze to the Iron Age. The concepts of health and social identity and relevant studies in Southeast Asia are discussed in Chapter 2. A review of the hypotheses that will be tested in this thesis closes the chapter.

Chapters 3, 4 and 5 delve into the development and methodology of a health index. There is a discussion of health assessments and the introduction of the concept of the health index and its limitations. A new health index is developed for use in Southeast Asia by examining possible health attributes that can be included in an index. This chapter provides the methodology for the SEAHI (Southeast Asian Health Index) and is tested on sites in Thailand: Noen U-Loke and Ban Non Wat.

Chapters 6 and 7 concentrate on social identity. Archaeological and social theories are discussed, as are conventional methods of identifying social status. The ability of archaeologists to identify status in the archaeological record is considered. The methodology used in this thesis to determine social identity is detailed. This methodology is also tested on the sites in Thailand: Noen U-Loke and Ban Non Wat.

Chapters 8, 9 and 10 consists of the synthesis of health and social identity determinations based on the two sites and provides individual life histories. The hypotheses are addressed, as well as future research directions, in the last chapter.

1.3 Context is (almost) everything

It is important to understand the context of any archaeological site that is being investigated. Within an archaeological site, occupational floors, fill, artefacts, pits, post holes and burials may be separate items or archaeological constructs, but combined provide valuable contextual information. For example, an ancient ceramic vessel on display in a museum that has no provenance or contextual information is ineffectual in its ability to provide information about the past beyond its material makeup. It is an object with little relevance. With contextual information, that same ancient ceramic vessel can be chronologically dated due to its relation to occupation floors. The charcoal found in an oven pit, cut through the occupation floor, in which the vessel was sitting might provide an absolute date for the vessel. Based on the contextual information an archaeologist is able to determine that it was a domestic cooking pot used numerous times, and contained protein residues. Alone the sites studied may provide some valuable information, but within the context of other preceding and contemporary sites, the interpretations made are more constructive. The following chapter provides an overview of archaeological studies that have been completed in the region and provides a context for the current study.

1.3.1 Mainland Southeast Asian Overview

Mainland Southeast Asia has a long prehistory, but it has a comparatively short history of archaeological study, compared to European archaeology. Whilst there are political borders, more important for prehistorical studies are geographical regions where the climate, topography and environment can influence archaeology.

This study is focused on the Khorat Plateau, northeast Thailand, which borders with similar regions in Laos and Cambodia (Figure 1). Whilst mainland Southeast Asia is diverse, this background to the archaeology of the region will only take into account those areas and countries that are have a relationship with the Khorat Plateau: Laos and Cambodia. This is seen in terms of ease of access, similarities in environment, topography and culture. In this area, trade and social networks would have crossed the physical border of the Mekong River into

Laos, which would have also been used as a 'highway' into Cambodia. The Dangrek Mountains that are on the border of the Khorat Plateau and Cambodia would also have been used as routes for trade and social interaction. Historically, this relationship can be seen in the extent of the Khmer Empire (Briggs, 1951). The Khmer Empire, dating approximately 1200 to 500 years ago, spread from present day Cambodia through northeast Thailand and southern Laos into central Laos.

Within these regions, different terminology has been used to describe archaeological periods (Table 1). For the purposes of this study, chronological terms based on generalized technological advances will be used. These comprise periods belonging to the Palaeolithic, Neolithic, Bronze or Iron Age. The focus of this thesis is on the 'Bronze Age' and the 'Iron Age'. These terms can be problematic, at least in part, because the focus is so specifically on metallurgical technologies. Archaeologists, by contrast, generally accept that society and change within it is the result of numerous forces at work as well as technological change. Ideological changes as well as contact between different populations and changes in environment are all contributing factors. In addition, these technological factors are not considered prime movers for socio-cultural change.

The use of relative dating techniques has allowed these chronologies to be placed within specific sequential time periods. However, many of the dating techniques used in Southeast Asia have been questioned (Higham and Higham, 2009). Issues identified include utilizing charcoal from grave fill or non-contextual soils, the lack of adequate calibration methods, contamination or using a single date to determine a time period. With this in mind, known problematic dates that have been assigned to certain sites will not be repeated here; however, each site will be assigned to the broad technologically based periods: Bronze or Iron Age. Where dates are stated, the use of the term Before Present (BP) will be used.

Table 1: Terminology used in Southeast Asian prehistorical chronology (see Dunn, 1970, D. Bayard, 1984, Higham, 1996, Higham, 1998, Oxenham et al., 2001, Stark, 2004, King and Norr, 2006).

CHRONOLOGICAL TERMINOLOGY	ALTERNATIVE NAMES	
Palaeolithic	Hunter-gather Pre-Neolithic	Hoabinhian
Neolithic	Pre-Metal Mesolithic	Early Farming General Period A
Bronze Age	Pre-State Metal Age Metal Period Early Metal Period	General Period B Tamyae
Iron Age	Pre-State Metal Age Metal Period General Period C Mode 2 High Bronze Age Late Bronze Age	Muang Period Prasat Classic Phimai Late Prehistoric Formative

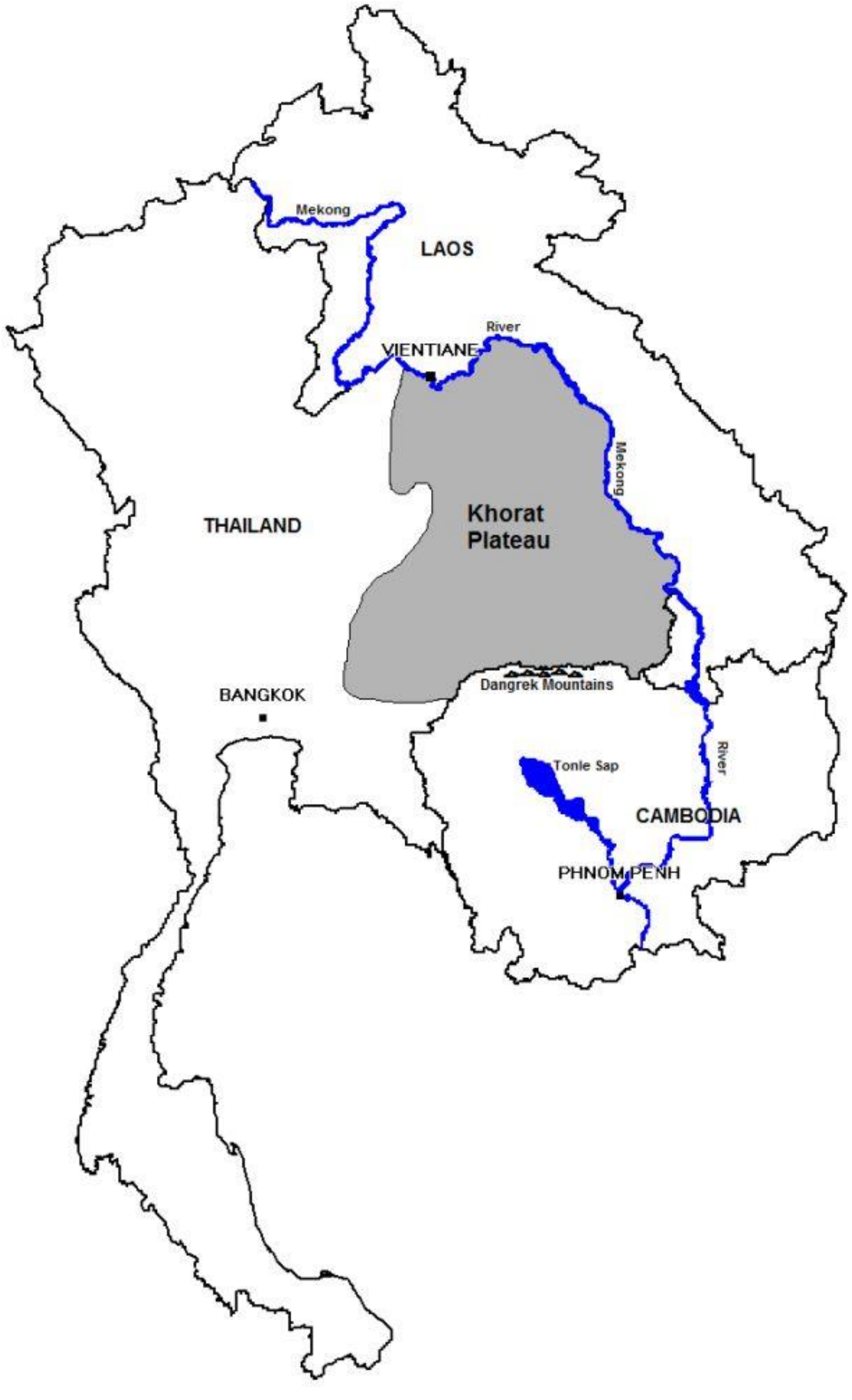

Figure 1: The physical boundaries of Cambodia, Laos and Thailand, highlighting the Khorat Plateau and the Mekong River.

1.3.2 Paleoenvironment

The environment is a contextual element of archaeological sites. Understanding of climate and vegetation assists in the interpretation of any changes in the archaeological record. There is little detailed information regarding the paleoenvironment of northeast Thailand, Laos and Cambodia, but research is ongoing. The following information is based on known paleoenvironmental as well as modern data.

The environment provides the basis for human survival and all of the factors within an environment will influence how a region is utilised. It is thought that the late Pleistocene was arid and it was not until the mid Holocene that humid conditions prevailed (White et al., 2004, Boyd, 2008). It was only when water was plentiful, in the late Holocene, that the environmental conditions allowed the beginnings of agriculture. The change of environment on the Plateau is significant. This coincides with the period identified as Neolithic. The first known habitation on the Khorat Plateau is in the Neolithic.

The Khorat Plateau, central and southern Laos and Cambodia today have a tropical climate: monsoonal with regional variations in the length of the dry season and amount of rainfall (van den Eelaart, 1976, Bell and Seng, 2004). The Khorat Plateau is characterised by a low relief, between 130 and 200 metres above sea level (a.s.l.), and is mainly gently undulating. Rainfall is highly variable, with the eastern half of the plateau receiving considerably more rainfall than the western half. The rainfall on the Khorat Plateau is generally lower than elsewhere in Thailand, Cambodia and Laos. The rainfall feeds into the river systems on the plateau.

The Mun River is a major river system on the Khorat Plateau (Figure 2). The two sites investigated in this thesis are located within the Mun River valley. Within the Mun River system, the relationship between hydrology, climate and vegetation has been identified by Boyd and Habberfield-Short (2007) and McGrath et al. (2008) (Table 2). The Bronze Age is characterised as a dry climate compared with present conditions. The inhabitants of the Khorat Plateau would have lived in and around the forests that were found there. A change in environment is seen in the Iron Age with an increase in seasonal rainfall. This would have impacted not only on the vegetation and on the ability of the floristic species to survive, but affected how human occupation in the area interacted with the environment. McGrath et al. (2008) argue that the Khorat Plateau is located within a rain shadow and any climatic change would have had significant impacts. For example, the increased flooding regime in the Iron Age would have required adaptation to the environmental conditions by modifying behaviour and the physical environment by controlling the water through earthworks. Any sudden cessation of the usefulness of those earthworks, as a result of drier conditions in the late Iron Age, would have then adversely affected the inhabitants, requiring another adaptation.

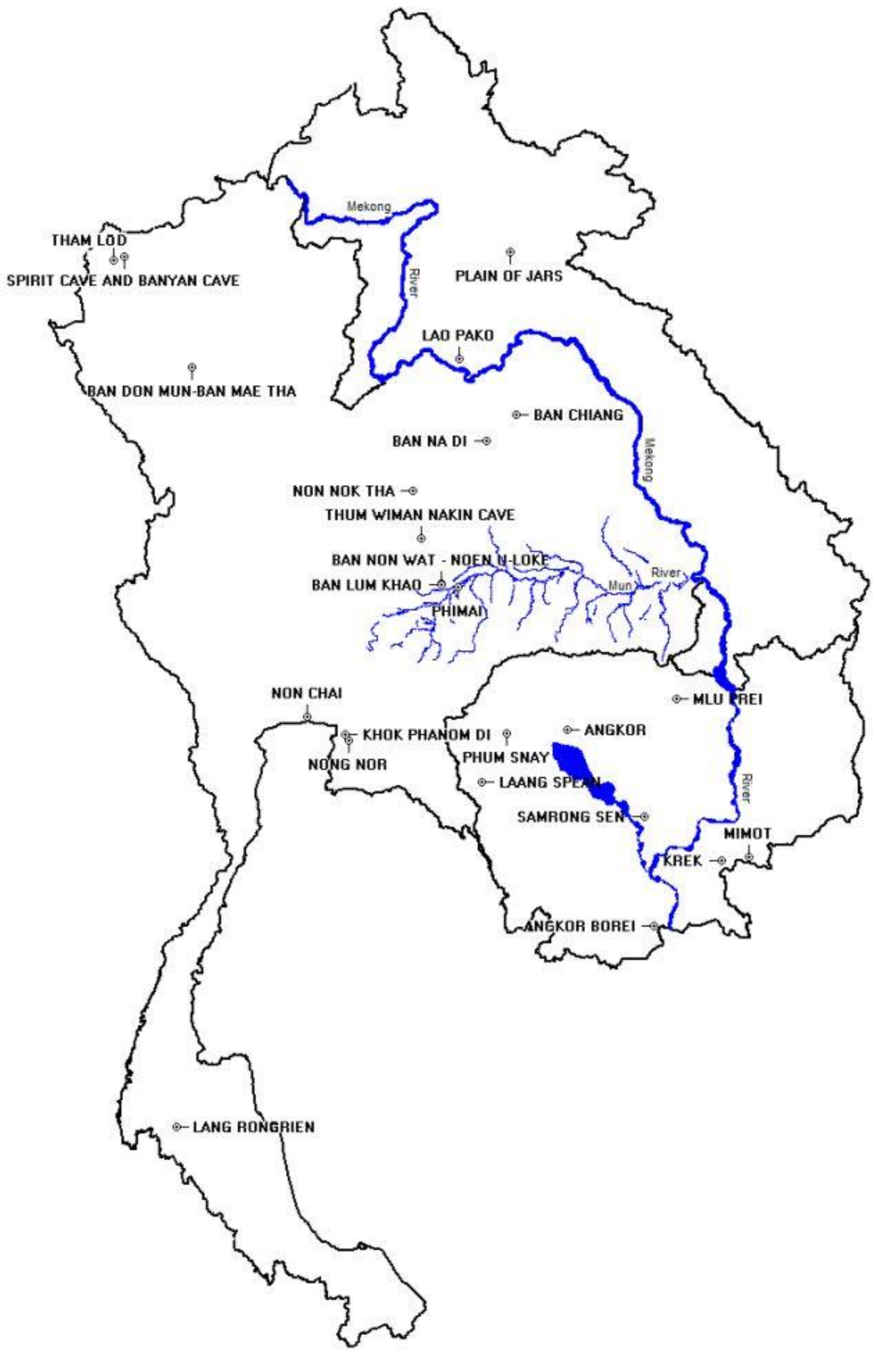

Figure 2: Location of sites mentioned in text.

In neighbouring regions there are commonalities. Central Cambodia is a flat basin, less than 100 metres a.s.l. The Tonle Sap dominates central Cambodia, being the largest lake in Southeast Asia, and the Mekong River runs through the country. It has a topography similar to that found in the Khorat Plateau, although the soils can be richer due to the large amount of silts being deposited annually by the Mekong and other rivers (Nesbitt, 1997). Laos is generally a mountainous country, but has extensive plains along the Mekong River that would be similar to the river valleys found on the Khorat Plateau.

Table 2: Paleoenvironment of the Mun River Valley (adapted from Boyd and Habberfield-Short, 2007, McGrath et al., 2008).

PERIOD	CLIMATE	ENVIRONMENTAL CONDITIONS / VEGETATION
Bronze Age	Significant reduction in rainfall, drier conditions than present	Native forest
Mid to Late Bronze Age	Seasonality of rainfall begins	Floodplain inundation
Early to Mid Iron Age	Periodic flooding	Dominated by *Cyperaceae spp* Both wet and swampy and dry grasslands Disturbed native forest
Mid Iron Age	Periodic flooding	Disturbed native forest and grassland Forest clearance
Late Iron Age	Flooding events decrease	Cultivation, grassland intensification

1.3.3 Early socio-cultural organisation and health

Evidence of human habitation on the Khorat Plateau can be first identified in the Neolithic. The Neolithic in mainland Southeast Asia is characterised as a hunter-gatherer society with some cultivation (Higham, 2002, M. Pietrusewsky and M.T. Douglas, 2002b). It is defined by the introduction of early farming associated with stone tool industry changes. Stone tools that come into use are common cultivation implements, such as hoes.

The mechanism that enabled the change from hunter-gatherer to agriculture has been debated. One argument is that the spread of agriculture from the Yangzi is linked to the spread of Austroasiatic languages (Bellwood, 2006). The early Neolithic farmers of Cambodia and Thailand are thought to have a common origin, and to have spoken the ancestral languages of the Khmer and Mon (Higham, 2001). If agriculturalists speaking these ancestral languages had travelled from China, they would have encountered hunter-gatherer groups in hills and along coasts. The commonly found Neolithic black incised ware pottery found in Yunnan, China down into Southeast Asia supports this hypothesis (Higham, 2002).

A number of archaeological sites associated with the Neolithic in Thailand have been investigated. Although not located on the Khorat Plateau, Khok Phanom Di is the most cited archaeological site that best demonstrates Palaeolithic and Neolithic populations (Figure 2).

Khok Phanom Di shows the transition from hunter-gathering to cultivation. It appears that the inhabitants of Khok Phanom Di utilized trade with agricultural groups to obtain rice and only later came to cultivate it as the local environment changed. Chang (2001) suggests that an agricultural community moved into the area, encountering an extant hunter-gatherer community. The hunter-gatherer community then merged with the agricultural one. This is supported by Vincent (2006) based on the ceramics found there.

The clusters of burials excavated at Khok Phanom Di have been determined to be familial and little status related differentiation was identified between them (Bannanurag, 1991). However, within families, it appeared that each individual was treated differently. Based on the irregularity of apparent status within family groups, Higham et al. (1992) argue that status is achieved and not hereditary. In later Neolithic periods women, especially, appear to become wealthier, possibly due to their role in the pottery industry. Stable isotope analysis provides a hypothesis that many women moved to Khok Phanom Di from elsewhere, which could provide an explanation of their ‘status’ (Bentley et al., 2007). Halcrow (2006) argues that the people of Khok Phanom Di are genetically distinct from those populations found in later sites in northeast Thailand.

The people of Khok Phanom Di suffered growth disruptions and anaemic reactions in childhood, especially when the settlement was being established, likely due to a malarial environment (Tayles, 1996, Tayles, 1999). Activity markers in the upper body also lessen over time, possibly indicating a move away from coastal shell fishing and canoeing.

1.3.4 Socio-cultural organisation and health in the Bronze Age

Bronze Age settlements have been the focus of numerous prehistoric archaeological investigations in Southeast Asia (Higham, 1996, Higham, 2002). Whilst there are many similarities between regions in Southeast Asia, there are also many differences. Every area was affected by the spread of agriculture and trade networks differently. The following details aspects of the Bronze Age on the Khorat Plateau that have been interpreted from archaeologically excavated sites, as well as comparison to settlements in other regions. The sites referred to in this thesis are shown in Figure 2.

Based on archaeological studies (Kijngam et al., 1980, Higham, 1996, O'Reilly, 2001), Bronze Age settlements on the Khorat Plateau appear largely autonomous, as there is no suggestion of regional centres with satellite settlements. This suggests a society that was not stratified (O'Reilly, 2003). Material or evidence relating to warfare and conflict has been used to identify stratified societies (for eg. Drennan and Peterson, 2006, Aranda-Jiménez et al., 2009). The lack of weapons found in archaeological contexts indicates that conflict was not common. However, this has been disputed (Higham, 2002). The argument that the Bronze Age was conflict free is debatable, as violence has been part of modern human makeup for thousands of years (Walker, 2001). Domett and Tayles (2006) did identify an increase of trauma, possibly from inter-personal violence, at Ban Lum Khao, but the majority of trauma in skeletons may have been the result of a change in activity from the Neolithic, such as increased farming and metallurgy.

Archaeological data relating to Bronze Age sites is dominated by cultural material excavated from graves. Occupational deposits compose a minor element of the knowledge base. Burials are the most common source of information regarding the Bronze Age and, as such, are mainly used to characterise the Bronze Age. Items found in burials include animal remains, ornaments, stone tools, shell jewellery, bronze and stone ornaments, terracotta jewellery, ceramics and clay figurines (Higham, 1996). Changes can be seen between early, middle and late phases of the Bronze Age within grave offerings. At Ban Chiang, in the early phases copper-alloy metals are used to make a wide range of implements and ornaments (Stech-Wheeler and Maddin, 1976). Later phases see bronze reserved for the manufacture of ornaments, many which are elaborate (White, 1982). Differences can also be seen between archaeological sites. Ban Lum Khao is contrary to many other sites as bronze ornaments were not used as grave offerings (Chang, 2004).

It has been argued that metallurgy came to China by way of trade routes with the Near East (Higham, 2001). Metallic goods and manufacturing knowledge, most probably then made their way south to the agriculturalists in Southeast Asia. As copper deposits can be found along the Phetchabun mountain range that borders the Khorat Plateau on the west, near Loei on the edge of the Khorat Plateau and in Cambodia and Laos, metallurgical production was able to begin at a local level in Southeast Asia (Jacobson et al., 1969, Shawe, 1984, Pigott et al., 1997, Thailand Department of Mineral Resources, 2002, Wu, 2008a, Wu, 2008b, US Geological Survey, n.d.-a).

Ceramics were common offerings in burials, especially red-slipped and cord-marked ware, such as found at Ban Lum Khao (O'Reilly, 2004). Historically, the study of mortuary ceramics has been descriptive rather than analytical. Typological studies have been the norm (Barribeau, 2011), but with technological advances, more analytical methods have developed (Sargeant, 2010). Studies suggest that ceramics, and other crafts may have been produced at the household level, rather than as a result of village or society level craft specialization (White and Pigott, 1996). Early phases at Ban Chiang are characterised by cord-marked ware and painted pottery. These types of pottery can be seen in other regions. For example, some of the ceramics found at Samrong Sen in central Cambodia are similar (Loof-Wissowa cited in Higham 2002: 156).

Other types of personal items found in burials include ornaments. The personal ornaments at Ban Lum Khao included shell beads, earrings and bangles, and marble bangles (Chang, 2004). Items that are considered unique were identified at other sites. For example, some of the Early Bronze Age burials at Ban Na Di were buried with clay animal figurines, such as cattle, deer and elephant as well as anthropomorphic figures (Higham and Kijngam, 1984a).

The type of faunal remains found in occupational deposits as well as grave offerings provides information about subsistence practices as well as the local environment. The animals exploited in the Neolithic, such as the wild water buffalo and deer became less common (Higham and Thosarat, 2004c). This indicates a change from hunting wild game to the utilisation of domestic animals. The faunal assemblage at Ban Na Di includes domesticated pigs, dogs, chickens and cattle, as well as wild animals, for example, water buffalo and deer, although some water buffalo may have been domesticated. The presence of deer bone in the mid to Late Bronze Age suggests that land clearance was not entire and forest areas remained (Higham, 2002). Hunting would have supplemented the rice-based diet. At Ban Lum Khao, pigs become more common through time, as well as dogs. Animal bones deposited in graves have been interpreted as ritual offerings. Animal offerings become more frequent in the Late Bronze Age. At Ban Na Di, there was only one burial in the Mid Bronze Age with an animal offering: a limb from a cow (Higham and Kijngam, 1984b). The Late Bronze Age had a variety of animal offerings including cattle, pig, crocodile and chicken.

The presence of occupational evidence and location of burial grounds have also provided information regarding land-use patterns. Bayard (cited in Douglas, 1996b) has concluded that there was only transient use of the Non Nok Tha, as the deposit is shallow and little occupational material is present. The presence of some occupational deposits and post-holes does suggest some domestic use of the location. It is suggested that the inhabitants of Non Nok Tha practised slash and burn agriculture, which would have necessitated abandonment of the location after a number of harvests to enable nutrients to be re-established in the soil. Bacus (2006) has suggested that the occupation site is located elsewhere and Non Nok Tha is just the burial ground.

Variations over time can be seen from other grave attributes, such as orientation of the body and associated grave goods. At Ban Lum Khao, the majority of the Bronze Age burials were arranged with their heads to the south-east, there are no bronze objects in the graves and the grave ceramics are in the distinctive ‘Prasat-style’ (Higham and Thosarat, 2004a). The Late Bronze Age sees body orientation turn to east-west and an increase in grave ‘wealth’. The Late Bronze Age sees more grave offerings with bronze jewellery, a wider range of ceramic forms, higher numbers of pots per burial, some trade items, and the addition of dog and fish bone offerings. There is also the introduction of new burial good types at this site, such as spindle whorls and a clay anvil. The Late Bronze Age has been identified as being statistical different from earlier periods based on grave goods (Higham and O'Reilly, 2004). Not all sites on the Khorat Plateau were similar. Higham and Kijngam's (1984a) analysis of the Late Bronze Age burials at Ban Na Di identified few bronze artefacts. Mainly ceramics, some jewellery and clay figurines had been placed in those graves. At Ban Non Wat, a number of the early Bronze Age burials have very large burial cuts and are surrounded by large number of ceramics (Higham and Thosarat, 2006). One grave has 80 pots of various size and quality. These have been labelled 'Superburials' (Stone, 2006).

The spatial arrangements of cemeteries are also indicative of aspects of society. At Non Nok Tha, clustering can be seen in the Mid Bronze Age graves (Douglas, 1996b, Douglas, 2006). Many have interpreted clustering in the Bronze Age as genetic affiliation. At Ban Na Di, there are two clusters based on the two areas (A and B) excavated and Higham (2002) found that all of the stone bracelets and clay figurines and the majority of bronze objects came from one cluster (Area B). This trend is seen in the Mid and Late Bronze Age and into the Iron Age. Higham (1996) argues that this shows that one household or family group was consistently 'richer' over time. Area B is located in the middle of the top of the mound, whilst Area A is located approximately 20 metres away on the edge of the mound apex (Higham and Kijngam, 1984b), suggesting that location may also be indicative of social standing. As Ban Na Di is a small excavation, any wealth designations based on spatial relationships would be difficult to determine. The results can only be regarded as being relative.

At Ban Non Wat, Mid Bronze Age burials are placed in rows and whilst the orientation of most is to the north, a small number are to the east. Higham and Thosarat (2006) identify those oriented east as having more mortuary wealth. Shell and marble bangles covered the arms of these east oriented burials. There was no differentiation between the sexes.

Mortuary wealth and status of individuals has been a significant focus for researchers. Burial goods are the main source of data used to identify social status associated with the Bronze Age. At Non Nok Tha, Bayard (cited in D.T. Bayard, 1984, Douglas, 1996b) argues that the presence of 'rich' burial goods in the graves of infants and children to be evidence of ascribed wealth; that is, status given to the child as a result of its genetic affiliation. In addition, due to the presence of particular ceramic types, there are two groups; one 'richer' than the other and this is also thought to be the result of genetic affiliation. Higham (1996) argues that the different ceramic types may not be chronologically similar and therefore indicate period of death rather than wealth. Bayard (cited in D.T. Bayard, 1984, Bacus, 2006) also arbitrarily divides rich and poor by the number of burial goods. Those with less than 13 artefacts are considered poor and those with more than 15 are classed as rich.

An analysis of differential social aspects of the Bronze Age burials[1] at Ban Lum Khao was completed (Higham and O'Reilly, 2004). Of the burials from the Bronze Age sample, only 40 could be properly assessed for ‘wealth’ status as they had not been disturbed and were fully excavated. Wealth was based on the number of burial goods per individual. They found that the ‘richest’ burial contained only 14 artefacts and as a result, there was little difference in wealth between burials. There was no difference between the sexes or age groups. Despite the methodological issues encountered, O’Reilly (2003) ranked the Ban Lum Khao sample, resulting in rankings of poor (95 individuals), middle (13) and rich (3). There was no difference in artefact types between the three groups, but the ‘rich’ burials had a larger quantity of artefacts. There were no signs of extreme wealth. The older members of the population were the poorest and many of the neonates were richer than infants or children. Ceramic types did not correlate with wealth. As some members were treated differently, but not so that there was a clear group identified with burial goods ascribing social power, O'Reilly (2003) determined that the population was not egalitarian or stratified. There was no evidence of a division of labour, except by sex, no institutional leadership or warrior class, or any other indications of social or ancestral power. At Ban Na Di there is some evidence of differential status within the Bronze Age. There is a crocodile skin shroud that was laid on top of a child and a pendant or tool that appears to have been fashioned from a crocodile cranium (Higham and Thosarat, 2004b). The crocodile is seen by Higham and Thosarat (Higham and Thosarat, 2004b) as symbolising a different status.

Outside the Khorat Plateau, in terms of symbolic items found in burials, the item that stands out at the coastal site of Nong Nor are the numerous dog crania used as grave offerings (Higham and Thosarat, 1998, Chang, 2001). They may have been utilised as a food offering or as totem or symbol of a sub-group, the latter being the explanation that Chang (2001) believes is most likely due to distribution patterns.

Another difference between the Khorat Plateau and neighbouring regions can be seen by comparing Nong Nor and Ban Na Di. At Ban Na Di, the burials are mostly in a north-south orientation and males and females were mainly placed in opposite directions: male crania were placed to the south and females to the north (Higham and Kijngam, 1984a). At Nong Nor the heads of the majority of both males and females are oriented to the east (Higham and Thosarat, 1998). Both north-south and east-west oriented burials can be found within the Khorat Plateau Bronze age settlements. This may suggest different cultural groups within the Khorat Plateau itself, as well as in neighbouring geographical zones.

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[1] Not including the Late Bronze Age. Higham and Thosarat (2004) have designated three mortuary phases: MP1, MP2 and MP3. MP 1 is Neolithic, MP2 is Bronze Age and MP3 is Late Bronze Age. Their assessment of social aspects only includes burials from MP2.

There are sample biases within most of the sites discussed in this chapter. Besides biases based on intactness of burials, other forms of bias are evident. The spatial and temporal patterns seen in many sites, such as at Ban Chiang and Ban Na Di, need to be taken as indicative only as they are based on small samples. At Ban Na Di approximately 65 m^2 has been excavated; at Ban Chiang 130m^2 was excavated, estimated to be 0.16% of the potential archaeological site; and at Non Nok Tha 339.5m^2 was excavated (3.1% of potential archaeological site) (Higham and Kijngam, 1984b, Douglas, 1996b). The site of Ban Non Wat has had over 900m^2 of area excavated. The larger the excavation, the more reliable the interpretation of temporal and spatial relationships. Sample size also affects our interpretations of population size and localised settlement health.

The ability to determine health of individuals and populations in Southeast Asian sites can be problematic for other reasons. Preservation of bone material can vary intra-site and inter-site. For example, at Samrong Sen in Cambodia, of the 20 burials that were excavated in 1901, only one skull is in good condition (Demeter et al., 2002). One hundred and eighty individuals at Non Nok Tha were examined in a health study by Douglas (1996b). They were placed into two chronological phases: early and late Bronze Age. In the same study by Douglas (Douglas, 1996b), 140 individuals from Ban Chiang were analysed. Domett (2004) analysed 110 individuals from Ban Lum Khao, as well as a number of human bones found not associated with burials (Domett, 2004). The majority of burials did not contain complete skeletons (Domett, 2004). Sixty three individuals at Ban Na Di were analysed by Houghton and Wiriyaromp (1984). Domett (2001) reanalysed the human remains and identified 78 individuals. The bones are in a moderate condition, being fragmented and many are incomplete. Tayles et al. (1998) analysed the 155 individuals identified from Nong Nor. The skeletons were in poor condition. Domett (2001) found determination of skeletal indicators difficult at Nong Nor. For example, a large number of adults were unable to be sexed, using pelvic, cranial, or even using metric measures of gracility and robusticity. It would be difficult to interpret population health as a result of the condition of the human bones. The differences in the ability to analyse health at each of the sites in Southeast Asia may limit the ability to compare population health.

In the study of individual and population health in burials at the different sites in Southeast Asia, a range of health indicators have been used. Dental health is commonly investigated, as it can be indicative of diet. A comparative analysis of Southeast Asian sites was completed by Newton et al. (2013). There are some temporal differences within the Bronze Age sites, but there are also general similarities amongst them that differentiate them from Neolithic and Iron Age sites. Overall temporal patterns in the Bronze Age saw a low to moderate frequency of wear and caries, low frequency of periapical cavities and a moderate to high frequency of ante-mortem tooth loss. At Ban Lum Khao, caries were few in number, although females had a higher frequency, which is attributed to the differences in diet between men and women (Domett, 2004). Outside the Khorat Plateau, females at Nong Nor also have a higher frequency of teeth affected by caries (Tayles et al., 1998). This indicates that women were likely to have eaten more carbohydrates and less protein than men. At Ban Chiang, later phases see an increase in caries in females (Douglas, 1996b). This suggests that the female diet changed and was dissimilar to the male diet. King (2006) investigated the diets of the inhabitants of Ban Chiang. Only a slight change in dietary variation over time was evident. There appears to be an increasing dependence on crops and a lessening variability in protein sources over time. King et al. (2013) identified that a high proportion of the diet of the inhabitants of Ban Non Wat was rice in the Bronze Age. Domett (2001) found low frequencies of dental pathologies in the interments at Ban Na Di. At Non Nok Tha, males had higher frequencies of dental pathologies overall, but female dental health declined dramatically from the early to late phase (Douglas, 1996b). Nevertheless, Douglas (1996b) considers the frequency of dental pathologies to be low.

Childhood stress can be seen in skeletal materials in the form of enamel hypoplasia as well as stature estimations. The frequency of enamel hypoplasia is low at Non Nok Tha and Ban Chiang and it appears that the growth potential seen in stature was attained (Douglas, 1996b). The stature of females at Non Nok Tha appears to increase in the later period. Conversely at Ban Lum Khao, older children (between age five and nine) had high incidences of linear enamel hypoplasia, which implies that either a chronic condition caused their death, or that the condition weakened them and then they acquired an acute condition, which led to their demise (K. Domett and N. Tayles, 2006). Houghton and Wiriyaromp (1984) found that incidences of enamel hypoplasia were low at Ban Na Di and that the individuals were relatively tall in stature. This evidence suggests a healthy childhood population. Later analysis by Domett (2001) found that childhood health was in fact poor. They suffered from chronic conditions as evidenced in the high frequency of enamel hypoplasias. Only four individuals (out of 73) were identified with hypoplasias by Houghton and Wiriyaromp (1984), conversely Domett identified a high proportion of teeth with linear enamel hypoplasia. The difference in interpretation appears to be the result of methodological differences. The assessment by Domett (2001) was based on frequency of affected teeth, whereas Houghton and Wiriyaromp (1984) based their assessment on frequencies of individuals affected. Despite this, Domett (2001) reasons that child mortality was not high, indicating that the children were strong enough to survive these conditions to adulthood. Differential access to food resources may be evident at Ban Lum Khao (Domett, 2004). Stature estimates show marked sexual dimorphism. Some males at Ban Lum Khao did not reach their genetic potential for stature. However, as there is wide variation within the male population, this suggests that access to resources for male children was more restricted than for females. This conclusion is further strengthened as the males of Ban Lum Khao are generally shorter than other Southeast Asian samples (K. Domett and N. Tayles, 2006).

Infectious pathological lesions do not appear to be common in the Bronze Age. Few specific infectious diseases were identified at Non Nok Tha, as most lesions were non-specific (Douglas, 1996b). Most infectious diseases were found in burials dating to the late phase. These include childhood ear infection and possible tuberculosis. Infectious disease was also identified in later phases at Ban Chiang (Douglas, 1996b). The skeletons from Ban Lum Khao have few signs of infectious disease (Tayles and Buckley, 2004). Pathologies are also uncommon at Ban Na Di (Houghton and Wiriyaromp, 1984).

Other pathological indicators include osteoarthritis. There is an increase in advanced osteoarthritis in males at Non Nok Tha in the late phase (Douglas, 1996b). The opposite occurs in the female sample. Severe joint disease was more prevalent in men than women at Ban Lum Khao, but women died at an earlier age and may not have had time to develop severe joint disease (Domett, 2004).

Trauma, in the form of fractures may be indicative of activities as well as accidents. The healed fractures found at Ban Chiang and Non Nok Tha are considered to be accidental rather than the result of violence, including warfare (Douglas, 1996b). At Ban Lum Khao, Domett (2004) investigated non-vertebral trauma and spondylolysis. Healed forearm fractures were prominent, especially in males. It is suggested that direct force as well as accidental falls may have been the cause and that in general they are activity related. Cranial fractures, of which there were two cases, are more indicative of inter-personal violence. There were eight cases of spondylolysis in the Ban Lum Khao sample, mainly in males. Whilst there is a relationship between heavy manual labour and spondylolysis, Domett (2004) argues that genetic susceptibility may also be an influencing factor. Four adults at Nong Nor, outside the Khorat Plateau, had healed fractures (Tayles et al., 1998). The individuals with arm fractures may have been the result of accidents or violence.

Palaeodemographically, Douglas (1996b) identified a stationary or slightly declining population at Non Nok Tha. This was also identified at Ban Chiang. Almost half of the Ban Lum Khao sample were sub-adults (Domett, 2004). This suggests a high mortality rate. In addition, based on demographic analysis there are also indications of a rapid population growth (K. Domett and N. Tayles, 2006). The life expectancy at birth of individuals from Ban Na Di was 22.8 years (Houghton and Wiriyaromp, 1984). At Ban Chiang, the life expectancy is 26.1 years and at Non Nok Tha it is 25.2 years (Pietrusewsky cited in Houghton and Wiriyaromp, 1984).

Summary of Bronze Age

The Bronze Age is characterised as a growing population localised in independent settlements in a changing environment, utilising new resources and technologies. Gender differences are evident in diet and disease and warfare is uncommon. The Bronze Age sites contain many types of goods, although bronze is not common to all settlements. It is not found in any of the burials at Ban Lum Khao. There is evidence that bronze goods are being cast at a village level. Ceramics are common in graves, but temporal changes are not evident as studies lack this information. Temporal changes within sites can be seen in head orientation and associated burial goods. An increase and diversification of burial goods is observed at the end of the Bronze Age when new types of goods are introduced. The fauna found within graves indicate subsistence changes from wild animal to that of domestic. Occupational deposits suggest that burials were placed within the village confines. Clustering of burials at some sites is suggestive of kinship ties, but clustering of burials in the Bronze Age is not common as most site graves are in rows. It appears difficult to assign wealth status to individuals in the Bronze Age, as it appears kinship ties are more important, although a small number of burials stand out in the Bronze Age due to the uniqueness of their burial goods, such as the crocodile shroud on the child at Ban Na Di and the 'superburials' at Ban Non Wat. Some differentiation between genders can be seen in the disparate head orientation found at Ban Na Di. Health has been interpreted as generally good, as indicated by relatively low incidences of chronic dental pathologies and infectious disease. Later phases, however, show slight differences between males and females in dental health. Stress is considered low in childhood, except at Ban Lum Khao where male children appear to have growth disruptions.

1.3.5 Socio-cultural organisation and health in the Iron Age

Iron use in Southeast Asia commenced around 2,500 years ago. It is not certain if iron was introduced to the population or if it was developed independently from China, but Higham (2002) believes that an introduction from Eurasia and China is likely. This technology quickly spread south and was useful as there were sources of iron in Thailand, Laos and Cambodia. For example, the Phetchabun mountain range (US Geological Survey, n.d.-b), and areas near Loei (Jacobson et al., 1969, Shawe, 1984) contain iron ore sources.

The type of iron found in archaeological contexts assists in developing the narrative of each community. At Non Chai, iron is seen in the Early Iron Age in small amounts as slag, an indication of local smelting. Local smelting becomes more prominent by the end of the Mid Iron Age (Higham, 1996). Whilst the soils in the Mun River Valley have lateritic qualities, they are generally considered to lack sufficient iron for smelting (Cawte and Boyd, 2010). The iron slag and furnaces at Noen U-Loke are not considered smelting sites, but smithing sites, where objects were forged (Higham, 2007a). Iron would most likely have been obtained from iron ore smelting communities to the west. Initially, and very briefly, at Noen U-Loke iron was used to create ornaments, but by the end of the Iron Age, it became valued more as a domestic material, for example, to be fashioned into a sickle or hoe (Connelly, 2007). Being a Late Iron Age site, the iron objects unearthed at Lao Pako, near Vientiane in Laos are mainly tools. None are decorative. Ornamental bronze can still be found (Kallen, 2004).

Another characteristic that separates the Bronze from the Iron Age in the upper Mun River Valley is the introduction of Phimai black pottery[2], which appears to be the result of village-level craft specialization. In general, the type of goods found in Iron Age burials differs from that of the Bronze Age. At Ban Na Di, the Early Iron Age sees an increased number and range of burial items, including trade items (Higham and Kijngam, 1984b). Bronze and iron are both present. The burial goods are diverse and can include beads, bronze jewellery, Sun Bear canines, iron tools, rice, and iron weaponry.

The development of moated settlements is considered unique to the Iron Age. Labour organisation is required to construct and maintain the moats; a task considered difficult to do in the Bronze Age due to the social framework of the time. Large-scale infrastructure construction is seen as a sign of a stratified society. The introduction of moated settlements infers a labour system that could only be galvanised by a more centralised form of government with an increasing population and agricultural surplus. These moated settlements can be found in the Mun River valley as well as away from the Khorat Plateau. There are five recognisable moats around the settlement mound of Noen U-Loke (McGrath and Boyd, 2000). There are moats around Ban Non Wat and around numerous mounds in the Mun River Valley (Higham, 2002). At Noen U-Loke, Boyd and McGrath (2001) state that there was large-scale environmental change during its occupation. Forests were being cleared in response to intensification of rice cultivation. The moats excavated around the mound were probably constructed as a response to this environmental change; to control water, especially during the wet season. Rice was difficult to grow without water control. Water control is also seen at Angkor Borei (Bishop et al., 2004). Floodwaters from the Bassac River, near Angkor Borei, rise every year and flood the entire region (Fox and Ledgerwood, 1999). In the rainy season there would not have been any dry areas, and people may have had to live on boats. There is evidence of a long distance canal at Angkor Borei that was constructed in the Early Iron Age and abandoned at the end of the Iron Age. Bishop et al. (2004) argue that the canal was mainly used as a mechanism for transport between two centres, but also to enable drainage of agricultural fields. Constructing such a long

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[2] Phimai Black is a formal name for black patterned, burnished ware.

distance canal would require large-scale organisation. Despite evidence of water control for the purpose of rice production intensification in the Iron Age, carbon isotope analysis has identified more dependence on rice in the diet of the inhabitants from the Bronze Age than the Iron Age at Ban Non Wat (King et al., 2013).

There have been few publications of excavations of Iron Age sites in Thailand, Cambodia and Laos compared to the Bronze Age. Many of the sites are problematic, such as the circular earthworks in eastern Cambodia, including Mimot and Krek. These sites have not been systematically studied and have contradictory deposits and dates (Albrecht et al., 2001). For example, Malleret’s (1959) assessment that these circular earthworks were Neolithic fortifications was based on surface finds as no metal goods were found, but since then they have been reassessed and are considered as a relatable group dating to the Iron Age (Haidle, 2001, Albrecht et al., 2001).

Temporal changes can be seen within the Iron Age period. Changes in ceramic types and ceramic production are evident at some sites. The majority of ceramics from Noen U-Loke are Phimai black ware (Voelker, 2007). Phimai black ware is not found in the earliest phases of the Iron Age at this site. There is little evidence for on-site ceramic vessel production at Noen U-Loke except in the earliest phase. At Angkor Borei, in the upper Mekong delta of southern Cambodia, the three Iron Age chronological phases are characterized by temporal ceramic changes (Stark and Sovath, 2001). Early Iron Age ceramics comprise three types of treatment: burnished, corded-marked or smooth surface. The burnished ceramics are also incised. Mid Iron Age ceramics have similar treatments but they are decorated by painting or incision. The late Iron Age sees a change in raw material used as well as new vessel types and surface treatments (slip and paint). It is also suggested that wheel made vessels are present. No wheel made ceramics are present at Noen U-Loke (Voelker, 2007). The ceramics at Phum Snay in north-west Cambodia include cord-marked or paddle impressed red slip ware (O'Reilly et al., 2004). Some are decorated with glaze, paint or are burnished. They seem comparable with the Mid Iron Age ceramics at Angkor Borei. Also found at Phum Snay are Phimai black ware, which suggests trade links over the Dangrek Mountains into the Mun River Valley (O'Reilly et al., 2008). In northeast Thailand, at Non Chai, ceramics comprise red-slipped ware and painted with geometric designs, the latter is considered a regional style (Higham, 1996, Higham, 1998). The red on buff painted ceramics found in Mid Iron Age levels at Ban Chiang are similar to those found at Non Chai (Rutnin cited in Higham, 2002). The ceramics at Lao Pako show a relationship with northeast Thailand. Kallen (2004) found that ceramics were made using a paddle and anvil, as is the custom on the Khorat Plateau. Ceramics found were similar to those found in Iron Age deposits at Ban Chiang and Ban Na Di, in form and decoration, but dissimilar to those from Noen U-Loke, located further south (Karlstrom, 2000, Kallen, 2004). Stamp rollers with the same patterns are found at Lao Pako, Ban Na Di and Ban Chiang. It is surmised that these three Iron Age communities belong to the same cultural group (Karlstrom, 2000).

Temporal changes in burial orientation have been recorded at two cemetery sites. Many of the burials at Phum Snay that were excavated in 2001 had a westerly orientation (O'Reilly et al., 2008). In 2003, graves were found with a different mix of orientations (O'Reilly et al., 2006). The 2003 burials appear to date later than the burials excavated in 2001. The earliest Iron Age burials at Noen U-Loke have mixed orientation in cardinal directions, followed by clustering of burials with a northeast orientation (Talbot, 2007). Clustering continues into the Mid Iron Age, but the orientation changes to north or south primarily. There are no apparent age or sex differences between those buried oriented north or south. The late Iron Age sees the discontinuation of burial clusters.

The transition from the Bronze to the Iron Age introduced new items into the archaeological record, as well as a change in the use of materials in daily life and in the burial ritual. An increase in trade is evident as most sites contain goods that cannot be sourced locally. Technological change can be seen not only in the introduction of iron, but in the manufacture of bimetallic goods (O'Reilly, 2001). Early Iron Age objects at Non Chai include Bronze bracelets and bells, crucible fragments, clay moulds and a small number of glass beads (Higham, 1996). The Mid Iron Age sees a considerable increase in the number of glass beads found. At Ban Chiang, bronze appears to have been used exclusively for ornaments rather than tools. Pots are intact and placed on top of burials. At Ban Non Wat, a large proportion of Iron Age burials have broken pots on top of the body. There is debate on whether or not the pots have been ‘ritually killed’ during the burial ceremony or the pottery was inferior or thin in section (C. Higham, pers. comm.).

Occupational deposits are not extensive in Iron Age sites as many materials of daily life do not survive well in tropical soils. Nevertheless, some indication of domestic life can be found. The site of Non Bak Jak in the Mun River valley being currently excavated shows promise of occupational deposits (K. Domett, pers. comm). Salt and metal working occupation floors were found in Ban Non Wat (Duke et al., 2010). Kallen (2004) concluded that the site of Lao Pako was used for rituals that involve ceramic deposition. There is also evidence of metal working and textile manufacturing, in the form of spindle whorls (Karlstrom, 2000). One of the few features identified at Phum Snay is a distinctive domestic feature: a hearth lined with bamboo (O'Reilly et al., 2006). The remains of clay floors have been found at Ban Non Wat, as well as furnaces with crucibles and rubbish pits (Higham and Thosarat, 2006). Wattle and daub structural components have been identified at Noen U-Loke (Chetwin, 2007). The exact nature of these structures is unknown.

Faunal resources changed in the transition to Iron Age due to many factors, including environmental and agricultural practices. The majority of data on faunal resources has been derived from burial offerings. Aquatic resources were utilised at Non Chai, located in a swampy habitat (Higham, 1996). Middens contain shellfish, turtle and fish. Other fauna includes cattle, water buffalo and pig. At Non Chai, there is also evidence of hunting wild animals, especially deer. The people of Phum Snay were buried with domestic animals, including the forelimbs of cattle and pigs, as well as fish (O'Reilly et al., 2006). Sexual differentiation was evident in the later period burials excavated in 2003. Water buffalo were placed with males and cows with females. Occupational deposits at Phum Snay illustrate the different types of fauna that were exploited from the environment, including deer, turtles, crocodile, boar and small mammals. The species found infer a forested environment at Phum Snay. A unique element of the Mid Iron Age of Phum Snay is the exclusive use of left forelimbs of cattle and water buffalo as burial offerings. Cattle and pigs dominated the faunal record at Noen U-Loke (McCaw, 2007). Deer and water buffalo are also exploited but temporally decrease in number. The decline in deer is probably related to the changing environment, land clearance for agriculture and associated reduction of the deer population.

The Iron Age has been characterised by an increase in social stress and conflict, seen in the numerous iron weapons (Sorensen, 1973), population increase and a hierarchical social system (O'Reilly, 2001). Power and, by association, warfare is often supposed to be a feature of a stratified community. Warfare may have occurred during the Iron Age, especially in later phases. This is evident at the site of Phum Snay. Swords and daggers were found in association with male burials, including a cache of projectile points in one grave (O'Reilly et al., 2006). The skeletons found at Phum Snay exhibit high levels of interpersonal violence compared to other sites in Southeast Asia, which is indicative of an increasing trend towards social friction in the development of larger, regional polities (Domett et al., 2011). Some evidence of inter-personal violence, which may be interpreted as warfare, includes bones with cut marks, blunt force trauma to the crania and fractures to the lower arms. By examining both the excavated skeletal sample and the unprovenanced material at Phum Snay, Domett et al. (2011) found many incidences of cranial trauma. Over 60% of males and 30% of females had evidence of blunt or sharp force trauma to the crania. Most were not perimortem (Domett et al., 2011). This, along with the weaponry found in the site, suggests that conflict was common, much more so than occurred in contemporaneous populations in northeast Thailand. Generally, indications of trauma at Noen U-Loke are low, although the condition of the bones is poor. An older female at Noen U-Loke suffered cranial trauma (Tayles, 2003), possibly indicative of inter-personal violence.

In addition, objects that have been interpreted as epaulettes were found at Phum Snay. The epaulettes were found on the shoulders of skeletons and are fashioned from recycled sherds and iron “horns”, with resin holding the horn in place (Baskin et al., n.d.). Based on historical costume, these appear to be military paraphernalia. The type of pottery vessel that was used for the epaulette has not been found in the site. Although the site has been looted, present day villagers also recall seeing bronze helmets (Higham, 2002). The emphasis on warfare at Phum Snay may be indicative of spatial bias within the site. Many bladed items and projectile points may have been used in daily life, such as hunting. Many blades have been identified as swords as they are over one metre in length (Domett and O'Reilly, 2009). In conjunction with skeletal evidence of interpersonal violence at Phum Snay, it is likely that these objects are related to social upheaval and consequential violence. Whilst blades have been excavated at Iron Age sites on the Khorat Plateau, such as Noen U-Loke and Ban Non Wat, they have not been interpreted as military objects, as there is little evidence of skeletal trauma related to interpersonal violence. Some exceptions include two potential cases at Noen U-Loke (Tayles, 2003, Tayles et al., 2007). In addition, it has been suggested that the moats surrounding numerous Iron Age settlements are defensive constructions (Higham, 2007b).

The Iron Age is traditionally presumed to be a time of far ranging trade networks. A maritime trade network between South and Southeast Asia is often quoted. The glass, carnelian and agate beads found in Iron Age sites in Southeast Asia have been identified as originating in India. Whilst there is evidence of this, some beads are likely to have come from more local or regional sources (Theunissen et al., 2000). The presence of the Phimai Black ware at Phum Snay suggests a regional trade network (O'Reilly et al., 2008). Previously, McNeill and Welch (1991 cited in Higham 1996) stated that this type of pottery was traded in the Mun River Valley and is only found in a 50 kilometre radius of Phimai itself. Its discovery in Phum Snay is significant. At the site of Krek in eastern Cambodia, glass bangles were identified (Haidle, 2001). Chemical analysis of the glass shows similarities to contemporaneous south Vietnamese and Indian glass. Few glass bangles have been found on the Khorat Plateau, but similar types have been found at a late Iron Age site in Kanchanaburi Province, west Thailand. An intensification of trade networks is seen in the Mid Iron Age at Noen U-Loke with the introduction of silver and gold trade items (Higham et al., 2007). Higham (2002) has stated that the artefacts associated with the large jars found in the Plain of Jars are related to the Iron Age sites of the Khorat Plateau. These Iron Age communities may have controlled trade between China and the Khorat Plateau. As the Plain of Jars and the Khorat Plateau have different mortuary rituals this suggests different cultural ideologies (Sayavongkhamdy et al., 2000).

The burial practices during the Iron Age in the Khorat Plateau and surrounding regions are varied. At Noen U-Loke, the body was placed upon a bed of rice. At Phum Snay, there was evidence of lining graves with resin and bamboo (O'Reilly et al., 2004). Whilst the majority of

Iron Age sites have inhumations, some communities practised other types of mortuary rituals. At the sites located at the Plain of Jars, the materials associated with these jars include beads, metal objects, ceramics and burnt human bone (Sayavongkhamdy et al., 2000). Therefore, these jars may relate to cremation rituals. It has been argued that these large stone jars found on the Plain of Jars are primary burial jars, but some people had been removed for secondary burial (Sayavongkhamdy et al., 2000).

Differentiation between individuals can be seen within a population in the Iron Age. Sex-related differences in the Iron Age are not largely evident, although there are exceptions. At Phum Snay, differentiation between the sexes could be seen in the burial goods in the Mid Iron Age (O'Reilly et al., 2006). In the small sample excavated, males were buried with metal blades, projectile points and water buffalo forelimbs and females had cow forelimbs, spindle whorls and semi-precious stones. No sex-related differences are evident at Noen U-Loke (Talbot, 2007).

Few health assessments have been completed on Iron Age populations in the region. Noen U-Loke on the Khorat Plateau and Phum Snay in Cambodia are two sites that have been analysed. At Phum Snay, Domett examined the skeletal remains (Domett and O'Reilly, 2009). Twenty two individuals were uncovered as well as over 134[3] stratigraphically unprovenanced individuals, which were looted from the Phum Snay site (Domett and O'Reilly, 2009). The unprovenanced collection contained only bone elements, as complete skeletons were not available. Over two excavation seasons, 120 Iron Age skeletons were identified at Noen U-Loke and examined by a number of researchers (Tayles et al., 2007). The bone condition of the samples is poor. The Noen U-Loke sample forms part of the current study for this thesis.

Iron Age dental health has been analysed and compared to other Southeast Asian sites. The dental health of the skeletal material, including the excavated and unprovenanced material from Phum Snay was recorded by Domett and analysed by Honan (2005) and Mapson (2008). The rate of caries in the site is relatively high in comparison to contemporaneous northeast Thailand sites, including the site of Noen U-Loke. Nelsen (1999) analysed the dental health of individuals at Noen U-Loke. Caries, alveolar disease and ante-mortem tooth loss is comparatively high compared to Bronze Age populations in the region (Tayles et al., 2007). Mapson (2008) analysed the adult dentition in Phum Snay and found differences in caries and wear rates between males and females, suggesting that females ate more cariogenic foods than males and men ate grittier foods. Whilst Noen U-Loke has poor dental health compared to prior Bronze Age populations, the site of Phum Snay has a higher frequency of caries in the female

[3] Based on Minimum Number of Individuals (MNI) from looted Phum Snay graves and sourced from the ossuaries at Wat Leu in Phum Snay and Wat Rajabo in Siem Reap.

population compared to Noen U-Loke (Newton et al., 2013). The overall percentage of caries in Iron Age sites is also different to that of Bronze Age sites of northeast Thailand, but are similar to the higher levels of caries at the Neolithic site of Khok Phanom Di and Man Bac in Vietnam (Mapson, 2008, Newton et al., 2013). Mapson (2008) also completed a Dental Pathology Profile for the adult sample of Phum Snay and compared it to the Dental Pathology Profiles of seven Thai sites ranging from the Neolithic to the Iron Age. No exact match of the Phum Snay profile with any of the Thai sites was identified, nor could any distinct patterns be found through time. Phum Sophy, a site located in the same region as Phum Snay, dates to the mid to late Iron Age. The dental health of Phum Sophy and Phum Snay were compared to a range of other Southeast Asia sites in Thailand, Cambodia and Vietnam dating from the Neolithic to contemporaneous (Newton et al., 2013). No distinct patterns were evident over time, with the exception of the decline in one aspect of dental health in the Iron Age as carious lesions increased. There are other indicators at Phum Sophy that dental health was improving with the declining numbers of individuals with Ante-Mortem Tooth Loss.

The dentition at Phum Snay and Phum Sophy also showed evidence of ritual ablation and filing of the anterior dentition (Domett, 2005, Domett et al., 2013). Whilst not an aspect of dental pathology per se, this interesting cultural practice may also be seen at Noen U-Loke (Tayles et al., 2007). A number of individuals were missing their lateral incisors, which may be agenesis or ritual ablation.

The Iron Age sees the earliest incidences of infectious disease. Systemic and non-systemic infectious diseases were present at Noen U-Loke (Tayles and Buckley, 2004, Tayles et al., 2007) . For example, leprosy was identified, and it is possible that tuberculoses were also present. Remarkable findings have resulted from the unprovenanced materials of Phum Snay. Domett and Buckley (2012) identified a crania with large and extensive lytic lesions that are unique in the sample of prehistoric Southeast Asia skeletal materials. A differential diagnosis identified either a carcinoma or a form of Langerhans Cell Histiocytosis. The identification of such a long term debilitating condition in a person is suggestive of a society that is capable of caring for those who are not actively contributing to society.

Patterns of osteoarthritis are used to identify possible Iron Age activities. Shoichet (2006) examined the joint disease dataset collected by Domett for Phum Snay. A high frequency of osteoarthritis was evident in the right arm, with the wrist being the joint with the highest prevalence. This was interpreted as a predisposition to being right-handed and more importantly, due to the osteoarthritis in the wrist, an effect of increasing warfare. Unfortunately, sex could not be determined for the unprovenanced material, which made up the majority of the sample. This result differs from studies of osteoarthritis in the Bronze Age of the region, where the elbow joint had the highest frequency, presumably due to farming practices. Unfortunately, the poor condition of the bones at Noen U-Loke prevented an analysis of osteoarthritis patterns.

The paleodemographic study of Noen U-Loke show that the population was growing (Tayles et al., 2007). The Noen U-Loke sample shows high mortality in early infancy, but less so in childhood. This suggests that children were healthier than infants. The adult mortality also suggests good health. Stature estimates from Noen U-Loke suggest that the inhabitants reached their genetic potential, as they were taller than the Bronze Age inhabitants of Ban Lum Khao (Tayles et al., 2007).

Summary of Iron Age

The Iron Age is not well understood as few well-preserved sites have been analysed. However, there have been some trends identified. The Mun River Valley has a dense concentration of Iron Age sites and Higham (2002) suggests that the increasing density is indicative of increasing population, intensified rice cultivation and social complexity. The iron found in the Khorat Plateau appears to have been forged locally, but may not have been smelted there (Cawte and Boyd, 2010). The range of goods found within burials has increased. Many of the goods, such as glass beads, were traded into the area from long distances, such as India and are perceived as prestige goods. Many burials are considered wealthy based on these goods. Some sexual differences can be seen between burial goods at Phum Snay and new ritual behaviours begin, such as laying the body on a bed of rice at Noen U-Loke. Based on Phum Snay, O'Reilly and Sytha (2001: 266) suggest that the relative wealth of the interred is consistent with the hypothesis that "…there is increasing wealth in Iron Age cemeteries, growth of exchange networks and an apparent rise in social friction".

The Bronze Age, of which the most substantial data are from northeast Thailand, appears to have a homogenous aspect to it, whereas the Iron Age does not. The communities of the Iron Age appear to be idiosyncratic. Phum Snay is different to those Iron Age sites found in northeast Thailand and Laos in many ways. The faunal assemblages found in Iron Age sites are indicative of the changing environment, where forests were rapidly felled to make way for agricultural land. Along with this changing environment, further transformation of the landscape occurred with the construction of moats and channels. These have been linked to water control, transport and defensive constructions. Overall, it is difficult to determine that the Iron Age was healthier or less healthy than the preceding Bronze Age. Whilst there are health issues with regard to dental health and infectious disease, demographic analysis shows a growing population. Dental health at Noen U-Loke appears poorer than at the Bronze Age site of Ban Lum Khao. The presence of systemic disease at Noen U-Loke, perhaps the first instances of leprosy and tuberculoses in the region, may be an indicator of the trade networks during the Mid to Late Iron Age. Trauma may also be increasing and evidence of warfare is apparent at Phum

Snay, but not in northeast Thailand.

1.4 Ban Non Wat and Noen U-Loke

The skeletal material and burial goods at the cemetery sites of Ban Non Wat and Noen U-Loke are the subjects of this study. This chapter provides further details of these sites.

1.4.1 Ban Non Wat

Archaeological studies of Ban Non Wat (Figure 3) have taken place over nine excavation seasons. Five excavation seasons were undertaken jointly by the University of Otago and the Fine Arts Department, Thailand under the direction of Charles Higham and Rachanie Thosarat. An area with a total of 892m^2 was excavated during this time and 637 burials were recovered (Figure 4). The depth of these excavations was between 3.5 and 6.5 metres. Ban Non Wat has also been excavated by a joint venture between The Thai Fine Arts Department, James Cook University, Kasetsart University, and Southern Cross University under the directorship of Nigel Chang, Kathryn Domett, Bill Boyd, Amphan Kijngam and Warachai Wiriyaromp. The present study focuses only on the burials excavated from the initial five excavation seasons. Detailed figures showing burial goods in context with the skeletal remains can be found in Higham and Kijngam (2012) and Higham and Kijngam (2013) and will not be reproduced in this thesis.

As Ban Non Wat is classified as a domestic occupation and cemetery site, the elements or features that may be found here could relate to skeletal remains, grave goods or those items used in the daily life of an agricultural village. The majority of the elements, however, are associated with the cemetery. Analysis of the burials and grave goods is being undertaken presently, but general differences can be summarised here.

Based on the information from the excavations, Ban Non Wat has been occupied continuously from the Neolithic to the present. In order to correlate individuals and their burial goods with specific technological time periods, radiocarbon dating has been used extensively on the site to date various materials, such as charcoal found in grave fill, rice chaff in pottery temper and shell. Higham and Higham (2009) have reviewed the dates obtained and argue that the dates from the shell material that is directly related to the burials themselves are the only reliable dates. The chronology shows a tight series of dates relating to the different technological ages from approximately 3,700 to 2,000 BP. The Neolithic lasted approximately c.600 years, followed by circa 600 years of Bronze Age, then circa 900 years of Iron Age. Each technological age has contextual differences, as summarised in Table 3.

The structure of society in Southeast Asian prehistory has perplexed researchers, possibly due to a lack of detailed information. Ban Non Wat may provide some answers due to the intensity of research conducted there. Higham and Higham (2009) argue that there were two periods of hierarchical development in Ban Non Wat. They took place in the Early Bronze Age (BA 1 and BA 2) and again in the Iron Age. This supposition is based on the quality and quantity of burial goods placed in graves during these periods. The Early Bronze Age (BA 1 and BA 2) burials contain elaborate, well-crafted pottery vessels that are numerous, as well as exotic goods. Compared with Mid to Late Bronze Age (BA 4 and BA 5), the burials contain numerous goods. The presence of elaborate burial ritual is suggestive of social manoeuvring for power. The Late Bronze Age (BA 5) and Early Iron Age (IA 1) are exemplified by the dense packing of burials. Higham and Higham (2009) suggest that this may also be an indicator of population growth.

The Iron Age burials are considered ‘rich’, compared with BA 4 and BA 5, due to the presence of exotic agate, glass and carnelian ornaments. Population growth and the presence of items of significance suggest the development of a hierarchical system. The question of whether a hierarchical system can be determined based on the burial goods needs to be examined further. This is further discussed in Chapter 5.

Eleven phases are identified chronologically, but one group of people do not easily fit into Higham and Higham’s (2009) time phase classifications. The ‘flexed burials’ lay in both a north-south and east-west orientation. They argue that the flexed burials are hunter-gatherers rather than farmers, as the burial practice is similar to that of other Southeast Asian hunter-gatherers who buried their dead in this manner. There are also differences in burial goods between the flexed burials and the Neolithic burials. The dating of the flexed burials does overlap with the Neolithic occupation (Higham and Higham, 2009). This suggests a community that incorporated incoming farmers (who also hunted) along with the local hunter-gatherer groups. Carbon isotope analysis of the majority of the flexed burial and the unique jar interred individuals from the Neolithic indicate a broad spectrum diet similar to that of a hunter-gatherers (King et al., 2013). As a group, the Neolithic burials are supine and extended in either on a north south or east west orientation or in jars. They are not buried in rows or clusters. They may represent the first immigrant settlers of Ban Non Wat.

The Bronze Age is divided into five sub-phases with obvious burial ritual distinctions between the earlier and later Bronze Age phases. One of the defining elements of the Bronze Age is the placement of interments in rows. They commonly lie in supine, extended positions with ceramics placed at the head and feet. A north-south orientation is frequently encountered, however some rows are found on an east-west orientation.

In the early Bronze Age there are also what is termed by Higham (Stone, 2006) as ‘superburials’. For these, the burial cut is quite large, being much larger than the body itself and the large space is filled with ceramics, many containing over 30 (Higham, 2002) and up to 80 vessels (Higham and Thosarat, 2006). Some graves appear to be secondary interments and in two cases two individuals are included in the same grave. Many interments have shell and marble bangles covering their arms.

Figure 3: Aerial photo of Ban Non Wat (Google, 20 October 2013a).

Figure 4: Location of burials at Ban Non Wat (from Higham and Higham, 2009).

There are also a number of infants buried in jars and the 2005-6 excavation season revealed a segregated row of infants, which may be evidence of differential spatial burial practices. Later periods of the Bronze Age are markedly different from the earlier Bronze Age. Ceramics change as do the type and number of goods placed in the burial. For example, the number of bronze or copper based goods diminishes. Another change seen in the Bronze Age is the diversity of burial ritual. Through the Bronze Age the variety in burial ritual increased, so that by the Late Bronze Age, there were multiple types of burial rituals taking place (Harris, 2010). Types of burials identified by Harris (2010) include interments in narrow coffins as well as wide coffins, and the use of materials in loose shrouds as well as some individuals being tightly wrapped in materials. The durability of textile materials also varied.

The Iron Age shows some similarities with the later Bronze Age periods, but the burial ritual is noticeably dissimilar. The landscape around Ban Non Wat alters in the Iron Age. A series of moats are constructed to surround the settlement site between 2,200 and 2,000 BP (McGrath and Boyd, 2000). There is also a change in burial ritual, as Iron Age burials are clustered closely. These lay in supine, extended positions, covered in broken ceramic vessels. The pottery appears to have been deliberately broken, as part of a ‘ritual killing' of the pot, but Higham (pers.comm.) suggests that the pottery made was thin and not strong enough to withstand the soil chemicals and pressure of being buried, resulting in breakage. Burial goods include pig trotters, water buffalo feet, glass beads and bronze jewellery. Many burials are conspicuous due to the quality and quantity of exotic ornaments.

Table 3: Summary of phases at Ban Non Wat (adapted from Higham and Higham, 2009).

PERIOD	DATES (BP)[4]	BURIAL GOODS	COMMENTS
Flexed Burials	3700-3000	Pottery, bivalves, stone adze. Dissimilar to Neolithic goods.	
Neolithic 1	3600-3200	Incised complex designs on pottery vessels, marine shell ornaments, pig skeletons and freshwater bivalves.	Bodies placed supine and extended. Lidded jar burials.
Neolithic 2	3200-3000	Less goods than Neolithic 1, globular cord-marked pottery vessels.	East-west orientation.
Bronze Age 1	3000-2950	Increase in number of burial goods Small ceramic vessels. Copper based artefacts. Shell jewellery.	Wooden coffins. Axes even in infant burial.
Bronze Age 2	2950-2850	Copper based socket axes, chisels and points, anklets, and rings. Up to 50-60 pottery vessels per burial, elaborately painted designs on pottery, exotic shell and marble ornaments.	Four distinct groups – found in rows. Burials wrapped in fabric with coffins, some burials partially exhumed and reinterred.
Bronze Age 3	2850-2750	Pottery vessels, but less painted than BA2. Exotic shell and marble jewellery. Copper based goods, such as axe and anklets.	Grave size increases. Rows, head to NE.
Bronze Age 4	2750–2650	Shell and marble goods are rarer than BA3. Smaller pots, cord marked and red slipped. bronze goods are rare, clay bivalve moulds for smithing .	Five clusters. Head to the north.
Bronze Age 5	2650-2370	Cord marked and red slipped ceramics. Spindle whorls and grey clays. Less shell than BA4. No bronze goods. Domestic animals.	North –south orientation.
Iron Age 1	2370-2050	Pottery is indistinct from BA5. Spindle whorls and grey clay, bronze objects, iron tools, bimetallic spears, glass, carnelian and agate, whole fish in pots.	Clustered.
Iron Age 2	2050-1750	Phimai black pottery. Exotic stone and glass ornaments.	Very few burials. Disturbed.

4 Calculated from calibrated radiocarbon dates based on BC/AD format (1950 - y_{CAL} AD= y_{BP}) or (y_{CAL} BC+1950= y_{BP})

1.4.2 Noen U-Loke

A multidisciplinary assessment of the Iron Age site of Noen U-Loke (Figure 5) has been published (Higham et al., 2007). The assessment of ceramics, however, is notably absent. Five phases of occupation were identified in the sequence based on stratigraphy (Higham et al., 2007) as well as numerous moats (Figure 5 and Figure 6). These five phases can be related to the phases at Ban Non Wat (Table 4 and Figure 7).[5] The majority of burials relate to the periods of Iron Age 1 and Iron Age 2. Only one burial was identified in Bronze Age 5. Of the 120 Iron Age skeletons identified, the condition of the majority of the sample was very poor (Tayles et al., 2007). This was mainly due to pottery being placed on the bodies and rice placed within the burial. The rice was unthreshed and when in contact with the bone caused demineralization of the bone (Tayles et al., 2007). Detailed figures showing the location of burial goods in context can be found in Higham et al. (2007) and will not be reproduced here.

Figure 5: Aerial photo of Noen U-Loke (Google, 20 October 2013b).

The Iron Age 1 period has been identified as period of progression from a mixed economy of farming and hunting to that of farming and husbandry (McCaw, 2007). In the early stages of Iron Age 1, iron and bronze jewellery can be found, as well as tiger teeth jewellery and a small

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[5] For clarity, the nomenclature used to describe the time and technological periods at Noen U-Loke will be the same as that used for Ban Non Wat and not that devised solely for Noen U-Loke in HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) 2007. *The Excavation of Noen U-Loke and Non Muang Kao,* Bangkok: The Thai Fine Arts Department.

amount of iron tools. The presence of wild animal teeth at this stage, in essence during the transition period between the Bronze and Iron Age, may be meaningful (Boyd and Chang, 2010). Could this transition period signify the stage when the population began to identify as agriculturalists with hunting losing some of its ideological power in terms of community identity? Environment is an important factor, as with deforestation, population increases and associated intensification of agriculture, impacts will be felt community wide. The ceramics found in Iron Age 1 show continuity with the Late Bronze Age period of neighbouring sites (Higham, 2007b). The cord marked and red slipped ware can be found in the Late Bronze Age and Early Iron Age of neighbouring Ban Non Wat and Ban Lum Khao. The Iron Age 1 burials are also not found in clusters.

Table 4: Comparison of mortuary phases at Ban Non Wat and Noen U-Loke.

TIME PERIOD (BP)	BAN NON WAT	NOEN U-LOKE
2650-2370	Bronze Age 5	NUL Mortuary Phase 1
2370–2050	Iron Age 1	NUL Mortuary Phase 2
2050-1750	Iron Age 2	NUL Mortuary Phase 3 and 4
1750-1550	Iron Age 3	NUL Mortuary Phase 5

The Iron Age 2 period is distinct in terms of burial practises and ceramic technology. Key changes include the presence of complete pig skeletons, exotic jewellery (made from carnelian and agate) and the distinct burial ritual of laying a rice bed beneath the interred. The clustering of interments found in this period may be indicative of population pressures and changing societal attitudes affecting burial rituals. These clusters are not buried on a cardinal axis, but are SW-NE orientated. Later in this period the burials are still clustered, but are mainly in a north-south orientation. Some burials are lined with clay. There is an increase in the number of bronze and other ornamental goods as well as ceramics. The ceramics are the characteristic high quality Phimai Black ware (Higham et al., 2007). Rice beds are seen at the beginning of this period but disappear by the end. The number of bronze ornaments decreases and iron implements are exclusively tools, not ornaments.

It has been argued that there is differentiation between grave clusters in terms of burial goods during Iron Age 2. For example, Higham (2000) notes that one burial cluster in the earlier stage of this period contained almost the entire collection of carnelian, but has no pots. However, there are only two clusters in this stage and this may not be reflective of differentiation.

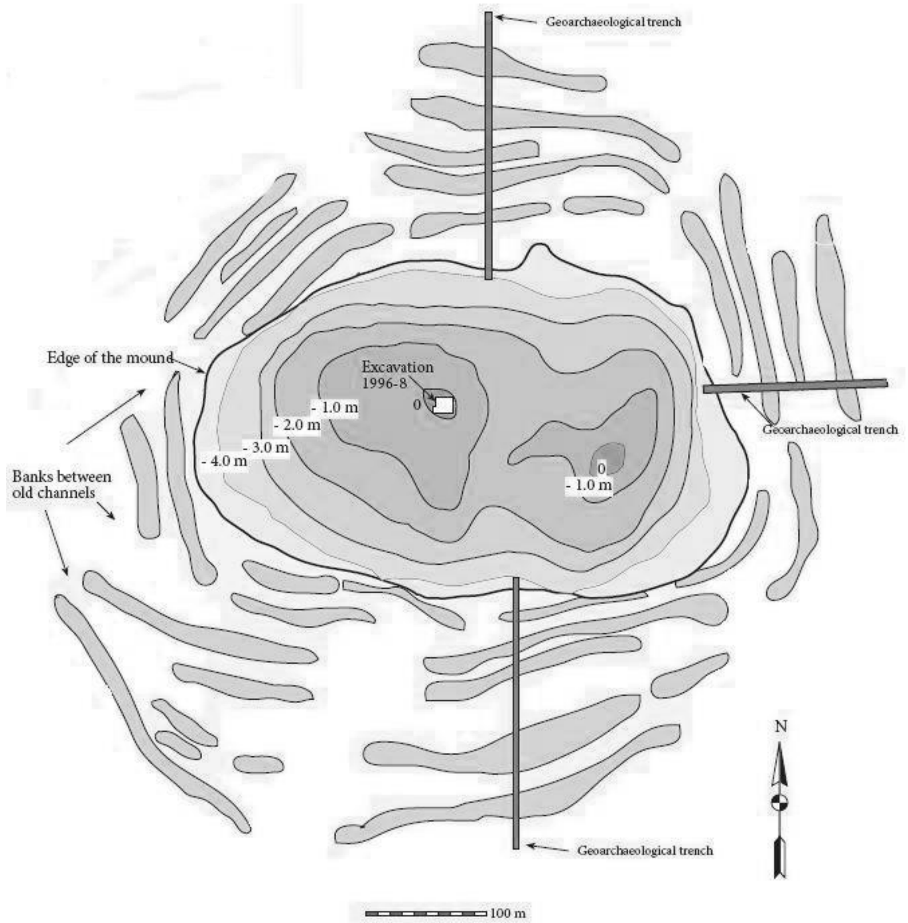

Figure 6: Noen U-Loke mound contour map, adapted from Higham and Thosarat (2007b).

The skeletal remains found in the burials were analysed and they provide insight into the health of the population (Tayles et al., 2007). Tayles (2003) suggests that the sample is an unbiased representation of the cemetery population. Demographic analysis of the Noen U-Loke sample shows high death rates in early infancy, less so in childhood. This suggests that children enjoyed a healthier status than infants, which would not be unexpected (Tayles et al., 2007). Adult mortality levels also suggest good health. Similarly the stature analysis of the inhabitants shows that they were taller than the Bronze Age inhabitants of Ban Lum Khao (K. Domett and N. Tayles, 2006), although there are genetic similarities between the two sites (Lertrit et al., 2008). Systemic infectious disease, as well as non-systemic, was present in a few individuals from Noen U-Loke (Tayles and Buckley, 2004, Tayles et al., 2007). The most likely causes of the systemic diseases were leprosy and tuberculoses. These may be the first cases of these diseases in the region. This was suggested by Tayles and Buckley (2004) who also suggested that there may have been wide reaching trade networks during this period. Trauma was also evident in the sample. Cranial trauma was found in one female, an older adult (Burial N99) (Tayles, 2003).

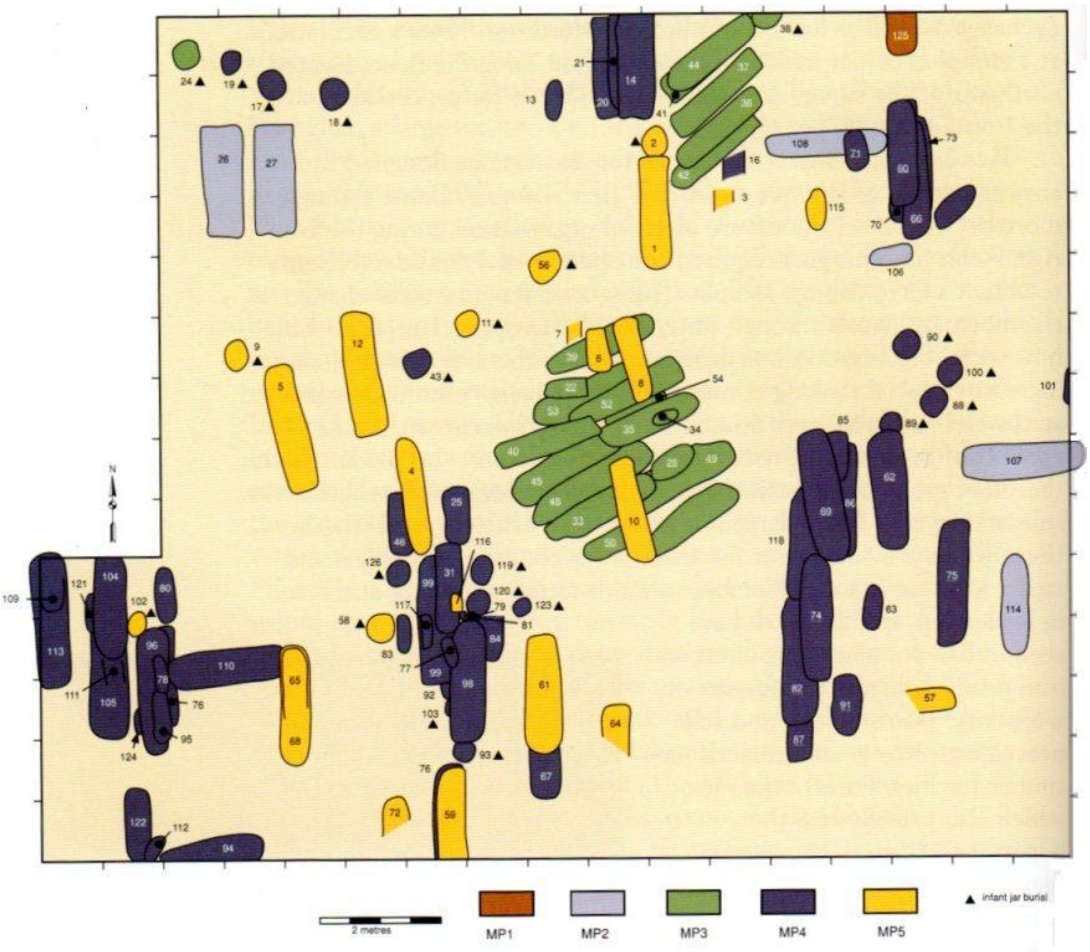

Figure 7: Plan of burials by NUL mortuary phase at Noen U-Loke (from Higham, 2002).

Rice was the staple food of the Iron Age in Southeast Asia. The rice would have been different to that eaten today as it would not have been polished (Tayles et al., 2000). Tayles et al. (2000) found that despite being an agricultural society, caries were not as prevalent at Noen U-Loke as at the Neolithic site of Khok Phanom Di. In a large portion of the world, there is evidence that with the introduction of sedentism and agriculture, population health declined (Cohen and Armelagos, 1984, Larsen, 1995). That is, the change from a hunting and gathering lifestyle to that of an agricultural one is detrimental to health (Hodges, 1987, Jackes et al., 1997). Tayles et al. (2000, 2009) show that this hypothesis may need to be reassessed. Newton et al. (2013) suggests that a decline in population health occurred later in Southeast Asia than other parts of the world, unrelated to the introduction of agriculture. Comparisons with the Bronze Age sample of Ban Lum Khao identified a relatively high presence of caries, alveolar disease and ante-mortem tooth loss in the Noen U-Loke sample (Tayles et al., 2007). Population based health assessments according to mortuary phases were not investigated at Noen U-Loke.

1.5 Transition from Bronze to Iron Age

Armelagos (2003: 34) states that "Bioarchaeology is at the forefront in documenting the evolution and adaptation of human populations and the disease consequences of changes that occur." The most prominent bioarchaeological study of transition in prehistory relate to subsistence change following the introduction of agriculture and its impact on population health. Armelagos and Cohen's (1984) seminal volume on the origins of agriculture engendered a focus for further bioarchaeological research (Cohen and Crane-Kramer, 2007, Pinhasi and Stock, 2011). Recent studies look at transitions other than those relating directly to the early phases of an agricultural society. This thesis also examines a technological shift: the transition from the Bronze Age to the Iron Age.

The Bronze Age was far more complex than previously considered and recent prehistoric research in Southeast Asia has revealed further insights (Higham, 2011). In many locations, new arrivals brought new ideas, including burial rituals. As those ideas are used by the new inhabitants and adopted by older residents, changes in the archaeological record can be seen. For example, in many sites in northeast Thailand, such as Ban Non Wat, burials appear to be clustered to some extent in the Neolithic, then there is a transition to burials in rows in the Late Neolithic and Bronze Age, and then again in the Iron Age there are distinct clusters of burials (Higham, 1998). The practice of burying people in rows in the Bronze Age may be suggestive of an influx of people into the region bringing new rituals/ideas.

The transition from Late Bronze Age to Iron Age can be clearly seen in the burial goods of Ban Non Wat. This is the period when wild animals became scarcer in burials and iron is used ornamentally. Iron was initially and briefly utilised in the Iron Age as jewellery and only over time did it became used exclusively used for tools (Nigel Chang pers.comm.).

Halcrow (2006) investigated the broadscale changes in prehistoric Thailand based on skeletal health and environmental changes. Studies of prehistoric farming communities around the world have shown that increasing sedentism and agriculture leads to an escalation in dental caries and poor dental health. In Southeast Asia this hypothesis is in doubt and Halcrow (2006) endeavoured to disprove it with a study of sub-adult demography and health in eight sites in Thailand: Khok Phanom Di, Ban Chiang, Non Nok Tha, Nong Nor, Ban Na Di, Ban Lum Khao, Noen U-Loke and Muang Sema. Muang Sema is a late Iron Age site, where little contextual information is available, but 30 burials were recovered during the excavation in 2000 by Leelamanothum and Thosarat (cited in Halcrow, 2006).

No clear change in health status can be seen during the intensification of agricultural practises. There are no clear changes in dental health or growth disruption patterns. Halcrow (2006) found that the earliest site, Khok Phanom Di, and the late Iron Age site of Noen U-Loke had high infant mortality in comparison with the other sites. These are at the opposite ends of the time line. However, an increase in infectious diseases can be seen over time. The individuals of Khok Phanom Di also suffered pathological conditions, but Halcrow (2006) cautions against assigning too much significance to this as the people were genetically different to the other populations, as suggested by M. Pietrusewsky and M.T. Douglas (2002b). There are pathological differences between the populations of Ban Chiang and Khok Phanon Di. Khok Phanom Di is located in a distinctively different environment and the inhabitants would have been subject to a different set of pathogens.

Based on the lack of marked health changes during the transition from hunter-gathering to agriculture in Southeast Asia, Oxenham et al. (2006: 285) states that "It would, therefore, appear that the major change in Southeast Asia in terms of human health in general and oral health specifically, should be sought at the transition from the bronze to the iron period." It is one of the aims of this study to identify this.

2 HEALTH AND SOCIETY STUDIES

2.1 What is Health?

There are many definitions of the word 'health'. For the purposes of this study, health is generally defined as the condition of the body and its functionality, which can be qualified with either 'good' or 'poor'. Being assessed as 'healthy' would be the same as being in good health. The World Health Organization defines health as "...a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 2006:1). Today, many of these factors can be assessed in real-time. In many parts of the modern world, medical and mental health professionals, as well as sociologists are monitoring the health of populations as well as individuals. In the examination of health of prehistoric peoples, this is not possible. There are no prehistoric medical records or questionnaires that can tell us about the social well-being of any person from prehistory. The question needs to be asked: What does the term "health" imply in a prehistoric setting? Can it refer to quality of life? A broad definition as seen in modern times may be inappropriate, but Larsen (1997:8) has provided one that is relevant to the study of prehistory:

> "Health is a composite of nutrition, disease and other aspects of life history. Contrary to medical models of health, stress and disease represent a continuum rather than a presence vs absence phenomenon, with respect to both the population and the individuals who comprise it."

This study examines the health history of an individual based on evidence that can be identified through the macro-examination of skeletal remains. Wherever health is discussed in the study of prehistoric remains in this thesis, this is to what it is explicitly referring.

There are questions that dominate studies of skeletal remains from prehistory. How can health studies of prehistoric sites be validated? What methods, used to measure health, are appropriate? Using all the available data that we have on aspects of health is the only option that bioarchaeologists have. Multi-attribute analysis provides the only valid and comprehensive form of assessment of health of individuals and populations based on the available data.

The types of evidence that skeletal remains can provide using macro-examination are wide ranging. There are numerous types of diseases and conditions that affect the skeleton, these include infectious disease, joint disease, metabolic disease, trauma and growth disorders. In most cases that involve pathological conditions, bone may only be affected if the condition is chronic in nature. These may be observed as osteoblastic or osteolytic lesions. Through comparison with modern examples of specific pathological conditions on skeletons, seen in the locational pattern of the lesions, some pathological diseases can be identified on prehistoric skeletons. Identification may be limited to disease groups, such as a treponemal disease, as they have similar lesion patterns. However, the majority of lesions found will be indeterminate. The duration of acute conditions does not allow for the formation of skeletal lesions. Whilst some researchers may see this as a distinct deficiency in health studies (Wood et al., 1992), it can be argued that acute illness has less effect on the living health history and quality of life of an individual than chronic illness.

Other forms of evidence can be seen in the teeth. Whilst the teeth cannot repair themselves as bone can, the developmental stage of teeth in utero, infancy and early childhood is informative. Adult teeth may show the effects of non-specific stress in the form of childhood growth arrest in tooth enamel (enamel hypoplasia). Other growth indicators can be seen in stature.

The implications of disease on a social level can be investigated to some degree in bioarchaeological studies. The World Health Organization (in Kallio, 1982: 2) defines the following:

> **"Impairment:** In the context of health experience an impairment is any loss or abnormality of psychological, physiological or anatomical structure or function."
>
> **"Disability:** In the context of health experience a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being."
>
> **"Handicap:** In the context of health experience a handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual."

The level of impairment, as a result of disease or other conditions may be difficult to determine, except in some circumstances. The handicap is the consequence of the disability that can include the relationship between an impaired individual and society. For example, an impairment of leprosy is the deterioration of the fingers. The disability is that they would have difficulty picking up objects. The handicap is the social stigma associated with the disease and effect that stigma has on the individuals daily life. This type of relationship cannot easily be identified within archaeological contexts, if at all (Dettwyler, 1991), but some inferences, such as whether or not an individual would have likely to have been dependant on the assistance of society in order to survive, can be made (Hawkey, 1998).

2.2 Social Identity

2.2.1 Socio-cultural organisation

Cultural anthropologists and archaeologists have used the theoretical framework of socio-cultural evolutionism (or neoevolutionism) to explain societies that exist today as well as those in the past (Service, 1962, Fried, 1967, Redman, 1978, Trigger, 1998, Barnard, 2004, Renfrew and Bahn, 2008): that is, that societies progressed from simple to complex. A number of variations of this progression have been produced (Table 5). Service (1962) and Fried (1967) provided the initial descriptions. Although they both have four categories of society, they are not directly analogous. Whereas Service (1962) attempts to describe different societies, Fried's (1967) terms are based on the mechanism within society. To illustrate this, Fried's earliest stage is "Egalitarian". Egalitarian, however, only relates to equality within the society, which was how the society operated. Renfrew and Bahn (2008) utilise Service's (1962) descriptions but have changed the terminology. This was probably due to the connotations of some of Service's (1962) terms. For example, Service's 'Tribe' designation is the same as Renfrew and Bahn's (2008) 'Segmented Society'. The word 'tribe' has a strong association with Paleo-Indians and pre-contact Australian Aboriginals. Others, for example, Redman (1978), have preferred not to use these broad categories. Redman (1978) sought to identify seven categories. Nevertheless, the terminology of Fried (1967) and Service (1962) has prevailed.

Hunter-gatherers and early farming communities are considered to be egalitarian (Barnard, 2004, Rousseau, 2006, Renfrew and Bahn, 2008). Egalitarian societies are defined as having no restriction of access to resources and individual authority is transitory. The 'simplest' society is that of a hunter-gatherer band. The term 'Hunter-gatherer' describes a lifestyle or mode of subsistence (Renfrew and Bahn, 2008). Food is procured by hunting wild animals or foraging for edible plants and shellfish. The societies are often thought of as highly mobile or semi-sedentary and are adaptive to environmental conditions. In contrast, farming communities obtain food from domesticated animals and agriculture. Farming communities may also procure wild foods. Even in modern urbanized societies there may be an element of a hunter-gatherer lifestyle in the diet. Early farming societies are termed tribes or segmented societies. Bands and tribes are thought to exhibit little wealth or power differences between inhabitants, except those based on age and gender (Daniforth, 1999).

Table 5: Terminology used in socio-cultural evolutionary context (adapted from Redman 1978).

<table>
<tr><th>SERVICE’S TERMINOLOGY</th><th>FRIED’S TERMINOLOGY</th><th>RENFREW AND BAHN TERMINOLOGY</th><th>REDMAN’S TERMINOLOGY</th></tr>
<tr><td rowspan="2">Band</td><td rowspan="3">Egalitarian</td><td rowspan="2">Mobile hunter-gatherer groups</td><td>Mobile hunter-gatherers</td></tr>
<tr><td rowspan="2">Sedentary and mobile intensive hunter-gatherers</td></tr>
<tr><td rowspan="2">Tribal</td><td rowspan="2">Segmentary</td></tr>
<tr><td rowspan="2">Ranked</td><td rowspan="2">Sedentary village agriculture and mobile husbandry</td></tr>
<tr><td rowspan="4">Chiefdom</td><td rowspan="4">Chiefdom</td></tr>
<tr><td rowspan="4">Stratified</td><td>Advanced farming villages</td></tr>
<tr><td>Temple-towns</td></tr>
<tr><td rowspan="2">City States</td></tr>
<tr><td rowspan="2">State</td><td rowspan="2">State</td></tr>
<tr><td>State</td><td>National States</td></tr>
</table>

Johnson’s scalar stress theory states that when egalitarian communities become large, they will inevitably become ranked or stratified (Hays, 1993). The amount of decisions required to be made when populations increase causes communal stress and either a group takes power or factions occur. It is then that political classes, such as seen in chiefdoms, become established. A ranked society is one where prized positions of standing within the community are limited, whereas stratified societies have been described as characterised by inequality and differential access to resources. Some of the signs of a stratified society that can be seen in the archaeological record are large constructions, including defensive structures, extensive agriculture and long-distance exchange of goods (Earle, 1987, Fagan, 1992). More recently these terms have become interchangeable, and a ranked society is seen as stratified (Renfrew and Bahn, 2008).

In the analysis of archaeological sites, most are determined to reflect either egalitarian or stratified societies. More recently, the egalitarian versus stratified dichotomy premise has been challenged (Flanagan, 1989). The concept of heterarchical society has been put forward. Swanson (1971: 45) states that heterarchy “…consists of units that have considerable autonomy in their internal affairs…” This concept states that heterarchical societies are not egalitarian or stratified, but flexible, where power relationships are complex and constantly changing (O'Reilly, 2001, O'Reilly, 2003). Heterarchical societies have been identified in Mayan sites

(1995), as well as in Europe (Scarborough et al., 2003). The concept has been examined in Southeast Asian contexts by White (1995) and O'Reilly (2003). This is similar to systems theory (Clarke, 1968, Flannery, 1972). One aspect of heterarchy is explained by O'Reilly (2001, 2003), who states that communities often value different things, for instance one community's economy emphasises metallurgy, whilst another's emphasis is ceramics. Different communities are often ranked according to their importance, but O'Reilly asks a valid question that in a heterarchical society is it possible to rank these communities relative to each other? Undoubtedly the answer would be no.

Arguably, a simple neoevolutionary view of human change over time is a flawed assumption, as humans are socially complex (Price and Brown, 1985). Modern ethnographic studies of various societies, from subsistence farmers to the hunter-gatherer !Kung of Africa, show that no one theory can explain their mechanisms or adequately provide a simple label to describe them, such as 'egalitarian' (Ember, 1978, Lee, 1979, Paynter, 1989). In fact, it is questionable whether a truly egalitarian society can exist (Flanagan, 1989).

Further, it would be difficult to explain all decisions made by a community as being based on rational consideration, as a neoevolutionary view might suggest. Humans have choice. Bender (1995) argues that inequality is the result of disparity of different members of a society to access social knowledge. It is more than likely that inequality began in the Palaeolithic within hunter-gatherer groups. Given the complexity of past societies, it unlikely that current neoevolutionary theory can provide the answer to questions regarding the mechanisms of past societies.

Despite the difficulties in determining the mechanics of past societies, archaeologists continue to use neoevolutionary labels in Southeast Asian archaeological studies. The Iron Age in Southeast Asia is considered to be comprised of chiefdoms and is stratified (Higham, 2002) and as the Bronze Age precedes this, it should be considered 'tribal' or egalitarian or partially stratified in nature. For the purposes of this thesis, the terms Iron and Bronze Age will be used, but only in a descriptive way. An association with specific social forms and types of organisation is not assumed.

2.2.2 Theory of Social Identity

Identity is a multi-dimensional entity. It is not homogenous in a population nor is it solely associated with a singular aspect, such as gender or socio-economic status. How an individual relates to and interacts with others is part of 'identity' (Brück, 2004). How others relate to that individual also defines part of their identity. The concept of 'agency' also plays a part in the assembly of an individual's identity (Dobres and Robb, 2000). Although 'agency' is an ambiguous concept, at its most basic level in an archaeological context, it can link the thought processes and actions of an individual, the material goods or artefacts, and social identity

(Dobres, 1995, Orser, 2011). The actions that any individual undertakes over a lifetime are influenced by their own concept of self as well as from a collective social group. That is, the individual may be the ‘agent’ and acts as a result of their own volition, or the agency may be a social group that obligates its mutual objective upon the individual. Some archaeological studies have linked gender and symbolism to agency (Dobres, 1995, Owoc, 2005). How to link the ambiguous nature of agency to material culture found in a burial context is highly challenging.

Social identity combines self-categorization with numerous other factors. Self-categorization is when an individual consciously recognises that they belong to a group or groups (Stets and Burke, 2000). It is their perceived similarities with that group that allows this self-knowledge and allows the formation of an individual’s identity. The focus is more on the role of the individual within that group rather than the group itself, although the role itself does not define the individual’s identity. Social identity can contain many of the following components or groups: gender, ethnicity, religion, location, economic status, political status, influence status, class, age and sex, and occupation (Bacus, 2006).

Gender as identity has been studied in prehistoric societies (Díaz-Andreu, 2005). Gender is a social construct that involves a set of principles related to gender, wider social perceptions, self-identification with a gender type, and associated behaviour. In archaeological and mortuary contexts, behaviour is expressed as activities that produce gendered objects or contextual information (Sørensen, 2000). The assignation of gender within prehistoric contexts can be difficult due to modern predilection to imprint modern gender values onto the past.

There are a number of types of identity (Knudson and Stojanowski, 2008) and any individual can have multiple identities, coexisting and shifting in time (Zvelebil and Weber, 2013) (Figure 8). Individuals may respond to their social identity in many ways. These are identity maintenance strategies that include protecting or redefining groups, and implementing measures to strengthen the group, or even leaving groups to alter their social identity (Brown, 2000). An extreme modern day example of the latter would be a person living in the slums of Calcutta moving to the Beverly Hills or vice versa. Immediately his or her perceived identity would change.

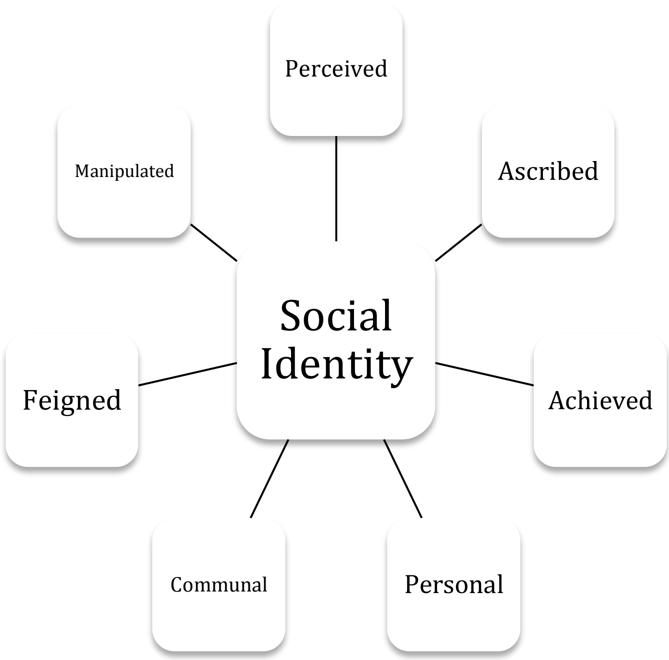

Figure 8: Aspects of Social Identity (from Knudson and Stojanowski, 2008).

Egalitarian, heterarchical and hierarchical societies contain individuals with different social identities. An egalitarian society is theoretically composed of a society where each person is considered relatively equal, however, when social identity is taken into consideration, can a truly egalitarian society exist? Perceived identity refutes the premise of equality. By its very definition, perceived identity is a product of humans examining one another and identifying differences between people. Individualism is a fundamental human trait. Where differences are found, equality is not. Flanagan's (1989) review of studies of egalitarian society demonstrates that there is some level of hierarchy in egalitarian societies. Hayden (2007) identified a number of models that have been used to explain social inequality related to cultural or environmental causality. The components of these models include:

- Cultural or personal values leading to inequalities
- Adaptations to availability of food
- Population pressures, including sedentism and territoriality
- Control over trade, goods and resources, including relationships
- Control of agricultural and pastoral land
- Political self-interest in the management of labour

Hayden (2001) argues that whilst the two main causality models, cultural and environmental, empirical data is required in order to understand evidence of inequality and its causes. The identification of social identity is crucial in identifying social inequality within a population.

In this thesis, social identity is considered. In an archaeological context, evidence of social identity can be seen in a number of ways. These can be found in cemetery sites in the skeletons themselves and in the burial contexts, such as grave goods and placement. Not all aspects of an individual's social identity can be recognized archaeologically. Some aspects that may be included are age and gender, ethnicity, location, and possibly occupation and economic status.

Many archaeological studies view social identity purely as economic status or wealth. Wason (1994) argues that if an artefact type is found only in a burial context and not in domestic contexts, or non-mortuary contexts such as in settlement areas, then in most likelihood, that artefact is a status marker. Status is a form of ranking. Economic or political status cannot be directly attributed to an individual in a prehistoric site based solely on the number, diversity or quality of burial goods due to problems with interpretation. Put simply, the deceased did not place the burial goods in the grave, another person did. The goods may not actually reflect the person's economic status or occupation, but may be the mourners' perceived view of that person, of themselves or even of power manoeuvring by mourners (Parker-Pearson, 1999). Often archaeologists superimpose their own beliefs and value judgements onto what they uncover.

One theory of burial good placement is that during periods of instability, possibly due to political upheaval or power manoeuvring, the amount of burial goods and their quality increases due to jockeying for positions and power by the survivors and their groups. This is a form of social competition or negotiation (Cannon, 1989, Kamp, 1998, Keswani, 2005, Oestigaard and Goldhahn, 2006). In times of stability, burial goods decrease in number as there is no need to show, prove or manipulate power systems. Therefore, a simple interpretation of social identity cannot be made by simply looking at the numbers of burial goods a person has. An understanding of the population as a whole is required. This can only be achieved by investigating the burial goods and occupational-related artefacts of the population sample during different time periods, rather than at an individual level. A discussion on burial goods is presented in Chapter 6.

2.3 Health and Society Studies in Southeast Asia

Bioarchaeological studies that attempt to fluidly combine and interpret health and societal indicators are a recent trend. Studies around the world include those on biological health and status indicators (Robb et al., 2001); mortality and status (Wu, 2008b); symbolic ritual behaviour and health status (Gamble et al., 2001); economic status, size and health (Schweich and Knusel, 2003); location, economic status and health (Pechenkina and Delgado, 2006); and dietary behaviour and health (Belcastro et al., 2007). These will be discussed in more detail in later chapters.

There are two theses that have looked at aspects of health and status in Bronze and Iron Age Thailand (Willis, 2003, Muth, 2003). Whilst they used different systems of status identification, they both identified only a few individuals that were considered to be ‘rich’, but incongruously they came to different conclusions regarding the society itself. One declared an egalitarian society and the other a hierarchical society. This highlights the problems associated with assigning status to individuals and social systems to populations based on status identification.

2.3.1.1 Relationship between health and society at Bronze Age Ban Lum Khao

Willis (2003) examined the relationship between social and health aspects at Ban Lum Khao utilising data from Domett (2001) and O’Reilly (1999). To analyse the health of adults and sub-adults at this site, the following health parameters were used: stature, linear enamel hypoplasia, caries and severe joint disease. In order to evaluate social status, a wealth index was constructed based on numbers of artefacts within four grave good categories: pottery, personal ornaments, jewellery and symbolic items. There are two individuals considered to be rich following the wealth index (Willis, 2003). Willis (2003) also suggests that there is a rich family based on O’Reilly’s (1999) data. Later burials are seen to be wealthier and it is believed that the egalitarian society is beginning to change to a more hierarchical one, although temporal designations in this thesis are challenging.

Willis’ (2003) found an inverse relationship between wealth and caries in females and sub-adults as well as between wealth and osteoarthritis in upper limbs in males. A significant positive relationship was identified between wealth and age.

This result implies that females and sub-adults who had caries were ‘poor’, as were men with upper limb osteoarthritis, presumably farmers if activity is causing the osteoarthritis. It is suggested that females with caries may have eaten more frequently, which made them more susceptible to caries. The significance statement indicates that the older you were, the ‘wealthier’ you were. Osteoarthritis is more common in older individuals and may be biased towards females. In context, this would mean that older females of good health were also wealthy. Willis identified the 40-49 years old age bracket of females as being the wealthiest. The link between age and wealth suggests that it is not wealth that is being tested, but possibly a link between burial goods, respect for an older individual, and their contribution to their family and society. As almost half the sample comprised sub-adults (47 out of a sample of 110), it would be interesting to see the outcome if the sub-adults were removed from the statistical equations, focussing instead only on adult wealth status.

Willis’ (2003) testing of relationships between social status and biological health is complex. Whilst there are difficulties in interpreting change over time, the significance testing of health indicators against wealth, where the sample was large, is useful.

2.3.1.2 Relationship between health and status at Iron Age Noen U-Loke

The relationship between health and status at Noen U-Loke was investigated by Muth (2003). In assigning social status to individual burials, Muth (2003) has applied a scale scoring system, where value is assigned to artefacts depending on their ranking. Artefacts perceived to be labour intensive, or imported are valued higher than easily made or obtainable objects. A complication is the presence of wide ranging trade networks (Higham et al., 2007). These networks may have allowed easy access to perceived high value objects. It would be difficult to work out the locations where items were procured or manufactured, as this is still being debated (for example see Theunissen et al., 2000).

The age, stature and dental health of individuals were used to assess health. The burials were then graded and placed on the wealth index (Muth, 2003). Two individuals were identified as being ‘wealthy’. On average, older adults are considered wealthier, but this is being driven by the female sample, as males actually become ‘poorer’ with age. This pattern is similar to what Willis (2003) identified at the Bronze Age site of Ban Lum Khao, as stated above. Only one relationship between health and wealth was identified. Those with a taller stature are wealthier, except for the tallest person.

Muth (2003) concluded that the wealth index created is inaccurate and states that the differentiation was not large enough to be able to distinguish wealth between individuals. It may be, however, that the results do accurately reflect the society, and that it was fairly egalitarian in nature. Nevertheless, based on the calculation that 95% of the burial goods in the site were buried with eight individuals, Muth (2003) states that Noen U-Loke was hierarchical and that eight individuals were wealthy. Muth (2003) determined that the ‘wealthiest’ burials had more artefacts in number, rather than having large numbers of rare items or those requiring high energy expenditure.

2.4 Hypotheses

In examining health and society, one of the main objectives is to obtain an insight into the quality of life of a community. Communities under transition are particularly interesting. One of the main objectives of this study is to investigate quality of life of two Southeast Asian communities undergoing the transition from the Bronze Age to the Iron Age. There is evidence for social change, intensification of agriculture and new technologies. In this transition period; did these changes result in health and general quality of life? Was it a negative or positive experience? The second main objective is to develop a methodology, a health index to enable these questions to be answered.

Based on current research, five hypotheses will be tested in this study. They are:

1. The health of the people of Ban Non Wat and Noen U-Loke improved from the Late Bronze Age to Iron Age.
2. Health differentiation can be seen between archaeological sites in the same region.
3. There is a correlation between burial treatment and health.
4. Correlation between health and burial treatment reflects social identity.
5. Society became more stratified from Late Bronze Age to Iron Age.

2.4.1 Hypothesis 1 -The health of the people of Ban Non Wat and Noen U-Loke improved from the Late Bronze Age to Iron Age

Neoevolutionary theory states that societies tend to follow a sequence of progression from an egalitarian tribal group to a hierarchical chiefdom and finally to a highly stratified state (Service, 1962). Creamer and Haas (1985) produced a comparative table of social unit and archaeological correlates in order to determine if the sites that they were studying in Mesoamerica were tribes or chiefdoms. Using the same definitions and correlates of Creamer and Haas (1985: Table 1) and based on current archaeological knowledge of prehistoric Southeast Asia, the Bronze and Iron Age is compared to these definitions. In terms of settlement, the Bronze and Iron ages are more similar to a tribal system as there is no centrally distinct location. Labour organisation appears to be tribal in the Bronze Age and transitioning towards a chiefdom system in the Iron Age. Other similarities of the Bronze and Iron ages with tribal systems can be seen in the poor evidence for surplus food production, community storage, stress and limited physical boundaries. The likeness to chiefdoms is seen in craft specialisation in both metal ages, and the evidence of status differentiation in burial ritual and status goods. Regional trade, a chiefdom trait, is also evident in both the Bronze and Iron Age, although longer distant trade manifests in the Iron Age only. This shows that aspects of the Iron Age are both egalitarian (tribe) and stratified (chiefdom), as is the Bronze Age. This comparison highlights how unclear definitions of the Bronze and Iron Age of Southeast Asia are to standard definitions of egalitarian tribal groups and stratified chiefdoms. Perhaps this indicates that a global interpretation is inappropriate and that regional analysis and narrative is more relevant.

Bioarchaeological studies have identified patterns of health status within egalitarian and stratified communities. It is anticipated that the inherent rules that an egalitarian society, such as generalised reciprocity, are there to preserve the society (Daniforth, 1999). This allows an equitable, healthy nutritional status. Studies in the United States (cited in Daniforth, 1999) of egalitarian societies have found a generally healthy society but some have identified high infant mortality, possibly from poor nutrition during pregnancy, as well as episodic stress, seen in the formation of Harris Lines. Larsen's (1995) review of health in agricultural societies compared with hunter-gatherer populations identified a number of patterns, although these are not claimed to be universal. These include higher frequency of pathological conditions in the skeleton, decrease in skeletal robusticity, and change in skeletal growth patterns. In addition it was also noted that females develop more caries than males in agricultural societies. It also can be seen that the initial development of communities, such as is seen in the transition from hunter-gatherer to farming may be detrimental to the health of the inhabitants as they struggle to adapt to the environment. The Neolithic site of Çatal Hüyük in Anatolia is an example (Lawrence, 1971). It is thought that the high incidence of porotic hyperostosis at Çatal Hüyük is due to a malarial environment, coupled with increasing stress on the body from farming as well as growth disruptions, possibly also related to malaria. Despite the stress, this community was able to adapt, as seen in the increase in life span of females from the site. In Southeast Asia, this may be seen at Khok Phanom Di (Tayles, 1999). Infant mortality is high in the early phases, and growth disturbances are evident in adults. Again, this is likely the result of the difficulties in establishing a community.

In the Mid to Late Bronze Age, Ban Non Wat is a well established community and stressors that affected the founding members of the community in the Neolithic should not be evident. As an egalitarian or heterarchical community in Southeast Asia, there should be a generally healthy population.

Earle (1987) reviewed studies of chiefdoms and stratified societies. Earle states that there is evidence of health differentiation between the 'commoners' and 'elite'. The elite would eat well in comparison with the commoner. This evidence seems to be based mainly on the work at Moundville in the United States, but Powell (cited in Daniforth, 1999) found the opposite to be true following detailed assessment of the site. Moundville has discernible elite burials, but differential health was nominal. Other health patterns in stratified communities that have been identified include an apparent decline in health as societies become more 'complex' (Ubelaker and Pap, 1998, Ubelaker, 2000). In the study of the transition from the Bronze to the Iron Age sites in Hungary, Ubelaker and Pap (1998) identified complex health status, where there was an improvement and a decline in health. Improvements include an increase in life expectancy, male stature and a reduction of cribra orbitalia and porotic hyperostosis frequency in sub-adults. A deterioration in health is visible in the decline in life expectancy for mid teenagers, higher frequency of dental caries in females, decline in bone robusticity, evidence of growth disturbance seen in higher frequencies of enamel hypoplasia and stature (in females) and a higher frequency of porotic hyperostosis and cribra orbitalia in adults. They argue that these health impacts demonstrate increasing social complexity, through population increase and reliance on agriculture.

The impact of dietary reliance on agricultural crops has been investigated in many parts of the world. In the Americas, where maize was the dominant crop of the early farming communities, there is a clear relationship between dental disease and agriculture. For example, carious dental lesions increased, especially in females (Larsen, 1983, Lukacs, 2008, Lukacs, 2011). In Southeast Asia, the main agricultural crop is rice. The relationship between a rice dominated diet and health, especially seen in carious lesions is not clear (Tayles et al., 2000, Domett, 2001, M. Pietrusewsky and M.T. Douglas, 2002).

The Bronze and Iron Age communities of Ban Non Wat and Noen U-Loke, appear to be reliant on rice as their main carbohydrate source, although to a lesser degree in Iron Age Ban Non Wat (King et al., 2013). In the Iron Age, water management measures are implemented, seen in moat construction, presumably for water control and future planning. Forests are being cleared to provide more space for crops. A wide ranging trade network is evident and craft specialization may be increasing. This is suggestive of some social stratification. Technological change is also occurring, seen in the presence of iron as well as gold and silver. Presumably, those individuals and groups who are competing for power and control of resources in the Iron Age would be proving their worth by providing reliable and steady provisions as seen in the water control and forest clearance. Few Iron Age health studies have been completed as yet. Whilst the studies that have compared Iron Age sites to those of the Bronze Age have identified some differences in health, it is not definitive. It is hypothesised that health status will improve from the Bronze to the Iron Age at the sites of Ban Non Wat and Noen U-Loke. The formulation of a Southeast Asian Health Index will be able to explicitly show if this is the case.

2.4.2 Hypothesis 2 - Differentiation of health can be seen between archaeological sites in the same region

The second hypothesis states that health can be differentiated between different archaeological populations within the same region. The sites of Ban Non Wat and Noen U-Loke overlap temporally in the Early Iron Age. This is the only period that can be tested for health differences.

Ban Non Wat, as indicated previously, is a well-established community, whereas Noen U-Loke appears to have been founded in Late Bronze Age. Noen U-Loke may have had some health difficulties relating to this late establishment. In a similar way in which the site of Khok Phanom Di appears to have had settlement establishment health issues (Tayles, 1999), Noen U-Loke had high infant mortality rates, most likely due to nutritional difficulties. Ban Non Wat, should not have significant nutritional difficulties. Environmental changes, seen in the Iron Age, would impact on a new community more than one that is well established and the inhabitants of Ban Non Wat should have adapted better to any change.

An early stratified community, as seen in the Iron Age of Southeast Asia, includes groups or individuals who had control over access to resources. Every controlling group is different. The leadership at the well-established Ban Non Wat community would have developed over a long period of time. The competition for leadership at Noen U-Loke would have been over a short period of time. As a result, the mechanism of authority would have been different at each community. This may be reflected in health (and wealth) status at each site.

Ban Non Wat and Noen U-Loke are located in close proximity (approximately 2.5 km apart) and there may have been inter-community relationships. A genetic analysis of the Noen U-Loke sample demonstrates a close genetic affinity with the inhabitants of Ban Lum Khao (Lertrit et al., 2008). These communities are approximately 9.5 kilometres apart. The cemetery at Ban Lum Khao was abandoned following the Bronze Age, during the establishment of Noen U-Loke. It is not suggested that the inhabitants of Ban Lum Khao moved to Noen U-Loke; simply that the inhabitants were from the same gene pool. The inhabitants of Ban Lum Khao may have utilised a new location for a cemetery in the Iron Age. The inhabitants of Ban Non Wat have yet to be genetically compared to either population, but it is probable that they are also genetically similar. Presently it is not known what radius of agricultural land around a settlement was ‘owned’ by each community. It is anticipated that there would have been some competition between the settlements in some form. This may involve competition over land, water and other resources as well as influence over trade. Success or failure in any of these competitions would have had an influence on health.

It is difficult to generalise about the health of the Iron Age archaeological settlements on the Khorat Plateau. Each settlement was different, and in some respects have unique qualities. For example, the existence of a craft specialist village would limit its ability to produce food for its inhabitants and therefore, that village would have to trade items for the surplus crops of another village. As a result, it would be reasonable to suggest that health would also be different between villages. During the temporal overlap of the habitation of Ban Non Wat and Noen U-Loke, it is hypothesized that they can be differentiated based on health status. The use of the Southeast Asian Health Index will enable a clear differentiation to be seen, if it exists.

2.4.3 Hypothesis 3 - There is a correlation between burial treatment and health

Numerous studies using a variety of methods have examined correlations between health and wealth. Based on an individual’s burial goods, wealth has variously been determined by number of artefacts, ratio of prestige to utilitarian goods, energy expenditure in the production of artefacts, and the number of symbolic items. Based on burial ritual, it is difficult to interpret and define the wealth of an individual. Whilst a count of artefacts may appear to be an easy measure of wealth, we cannot be sure of what is actually being measured. Is it the level of wealth, family grief or competitive behaviour of the survivors?

There has been some movement away from interpretations of ‘wealth status’. Social status studies, although a broad label, are becoming more popular. For example Robb et al. (2001) have attempted to look at correlations between prevalence of specific pathological markers and burial treatments at the pre-Roman site of Pontecagnano, Italy. Burial treatments are seen as an indicator of social identity. In order to identify status differences in their population samples, they presumed an explicit hierarchical social system where lifestyles differed markedly between the classes. Whilst no definitive correlation could be found between health status attributes, such as enamel hypoplasia, they could identify correlations between activity markers and burial treatment. They found that the males who were buried without grave goods shared high incidences of Schmorl's nodes, tibial periostitis, and trauma. The lowest incidences of pathologies were found in males with weapons, who appear to have suffered less physical stress. They argue that the males buried without goods are manual labourers.

By examining burial treatments, different variables of the burial ritual can be broken down into components or placed into various combinations. Components may include the different artefact types, head orientation, or even location within a cemetery. These components and combinations can be compared to health attributes as well as the health index score. By looking for relationships between these two variables, no assumption of wealth or status can bias the results. Unlike Robb et al. (2001), an explicit hierarchy is not evident in either Bronze or Iron Age Southeast Asia. It is not necessary to assume this in order to assign aspects of social identity to a person. For this study, wealth status is considered to be an inappropriate value judgment. Burial treatment may have been guided by the health of an individual. The third hypothesis is that there is a correlation between health, determined by the Southeast Asian Health Index, and burial treatment.

2.4.4 Hypothesis 4 - Correlation between health and burial treatment reflects social identity

Social identity does not rely on a hierarchical society to be identified in the archaeological record. Hierarchy is a generalised broad social system, whereas social identity is at an individual level. The latter is multifaceted and relies on many variables. Such variables include sex, gender, age, occupation and wealth. Social competition may impact on the level of ostentation of the burial ritual. Whilst this may inhibit social identity assessment, it also may be seen as an aspect of social identity.

It is accepted that aspects of social identity can be identified by burial treatment. It is difficult, however, to directly link burial goods to social identity as we may be uncertain of the true meaning of the burial goods themselves. As Robb et al. (2001) was able to demonstrate, study of the burial treatment correlations with health attributes is able to provide a better understanding of social identity. Their analysis of pre-Roman males in Pontecagnano, Italy, identified a group with weapon burial goods who appeared to have a better quality of life, seen in health status, than those who appear to be common manual labourers or a distinctively lower socio-economic group. This distinction is not seen in the female population, suggesting that roles for males were strictly controlled. Whilst the weapons burial goods may, in many contexts, identify the individuals as soldiers or warriors, the lack of skeletal pathologies in this group places doubt on this assumption. The weapons appear to be items of prestige and those with them likely lived a privileged life, seen in their good health status. It is not the weapons that permit a better understanding of their social identity, but the relationship with health. The narrative of social identity is clearer as a result.

The fourth hypothesis is that the relationship between health and burial treatment will reflect social identity. By looking at the relationship between health and burial treatment, we will be able to form a clearer picture of the individual.

2.4.5 Hypothesis 5 - Society became more stratified from the Late Bronze Age to the Iron Age

Many technological and environmental changes occurred in the transition from the Bronze to the Iron Age. Most obvious is the introduction of iron. Copper is easier to smelt than iron (Forbes, 1964, Moorey, 1994, Rehder, 2000). Iron ore needs much higher temperatures and does not become recognisably molten, rather a dense spongy mass that still contains slag. It is not until after the molten mass is forged intensively, cooled, reheated and forged repeatedly, that the slag is removed by force and what we recognise as iron is formed. It also becomes stronger after each reheating and cooling. This type of work would have been intensive and likely to be a task that is specialised.

Specialization roles, such as smelting iron ore and forging iron goods, cannot be accomplished at a household level and only a few inhabitants of a village, for example, would have the skills to forge iron objects. As a result, there are controls and limits on goods availability. This control of goods is an aspect of a stratified society. As specialisation of crafts, including pottery, metal objects and textiles occurs, so will stratification.

Another distinction between the Bronze and Iron Age is climate and environmental change. As flooding episodes decrease in number during the Iron Age, wet rice farming was becoming more difficult and deforestation was occurring. The deforestation may not have only have been the result of human interference by felling, but also general climate change. McGrath et al. (2008) have argued that the Khorat Plateau microclimate has a delicate balance and small changes can impact significantly on populations. The construction of moats occurred possibly in response to the reduced reliability of flooding. This adaptation would have not have been possible in an egalitarian society. A large labour force is required, and if important family members are taken away from providing subsistence to their kin as a result of these large works, there needs to be a reciprocal work agreement that would have been organised by a controlling figure or group. An agricultural surplus is required for this to occur. This suggests a number of work forces, including agricultural, manual labour, pottery, textile and metal working. When tasks are removed from the household level and are controlled at a community level, social stratification occurs.

The last hypothesis is that stratification within society increased from the Bronze to the Iron Age. Whilst this is a difficult hypothesis to test within the framework of this study, we may be able to see some indication of stratification, if it exists. By examining health and burial goods aspects of stratification may be identified.

2.5 Why a health index?

All five hypotheses discussed above utilise the Southeast Asian Health Index in order to test them. An issue regarding health interpretation of archaeological sites has been the incompatibility of many of the different health studies. The methods to assess health in skeletal remains are various and many. Numerous studies have looked at the health of archaeological populations by using a small number of variables (for example, Facchini et al., 2004, Obertova, 2005). Obertova (2005) studied the incidence of enamel hypoplasias in the dentition to interpret health, whereas Facchini et al. (2004) examined the skull for cribra orbitalia, cribra cranii (porotic hyperstotic lesions) and linear enamel hypoplasia. As each researcher uses their own method for determining health, an effective comparison of overall health between sites or regions is difficult (Kjellström et al., 2005). Recently, researchers have pursued the regulation of health interpretation by developing a standardized health index (Steckel et al., 2002b). The Western Hemisphere Health Index (WHHI) is limited to use in the western hemisphere therefore an undertaking of this study is to devise a simpler health index that can be used in Southeast Asia: the Southeast Asian Health Index (SEAHI). The scoring method for each attribute within the SEAHI needs to be clearly understood and easily observed and calculated by researchers working on archaeological skeletal material in Southeast Asia. This ranking system will be modelled upon the health index devised by Steckel et al. (2002b), as both indices are based on current knowledge of paleopathology. The viability of the use of this type of index in Southeast Asia will be examined within this study.

3 DEVELOPMENT OF HEALTH INDEX METHODOLOGY

The following chapter reviews the relevant background information relating to the development of the health index methodology used in this thesis. The reasons why alternative methods to measure health are needed are presented first, followed by a review of the health index that inspired this health study, then a general discussion of the limitations of health indices.

3.1 Health Assessments

Bone is a dynamic, living tissue made from a composite of inorganic and organic material (Mays, 1998). It is integral to the human body, and performs many functions, including providing internal structure and as an anchor for muscles, which enables movement. Being adaptive, it responds to biomechanical stress and other factors, such as trauma and disease (Ruff, 2000). For example, when there are biomechanical stresses on a bone, such as through physical exercise, new bone may be formed as a response and the bone appears robust and muscular attachment points on the bone become well defined. Conversely, if little stress is placed on a bone, such as seen in bed-ridden hospital patients, bone resorption may occur and the bone appears to waste away (Mays, 1998, White and Folkens, 2000). It also has been suggested that there can be systemic changes to bone structure as a result of biomechanical stress (Lieberman, 1996). Lieberman (1996) identified a systemic thinning of the cranial vault based on biomechanical stress: hunter gatherers had thicker cranial vaults than agriculturalists, who had thicker cranial vaults than post-industrial populations. The numerous varieties of stressors that can affect a person over their lifetime may alter their skeletal system. This is especially evident when resulting from chronic conditions and diseases.

The structure and mechanism of dentition is different to bone. Composed mainly of inorganic material, enamel surrounds a core of dentine tissue (Mays, 1998, White and Folkens, 2000). The high inorganic composition of the teeth do not allow for adaptation. Despite being highly resilient, unlike bone, enamel cannot remodel itself if damaged. Before the tooth erupts, the enamel undergoes a process of growth and calcification within the jaw. This process may be interrupted due to different types of stressors on the body, such as nutritional deficiency. The interruption to the enamel growth leaves permanent markers. Once eruption takes place, the teeth are immediately subject to wear and other factors that may permanently alter the teeth.

There are numerous physical conditions that can leave characteristic marks on bone and teeth, such as aging, disease and trauma (Ortner, 2003). Whilst these and others will be discussed further in their respective chapters, what they share in common is that they are used by bioanthropologists to determine the health status of archaeological populations and individuals. Using the various skeletal indicators, such as lesions and caries, bioanthropologists may be able to identify dietary history, specific diseases suffered and activities of individuals, as well identifying demographic change, the spread of disease and relationships between behaviour and environment.

Bioanthropological analysis is not lacking in difficulties and conundrums. One issue regarding health interpretations of archaeological sites has been the incompatibility of all of the different health studies. There are numerous methods of analysing health as there are for recording variables. There is a question of whether or not different archaeological populations that have been analysed using different methods should be compared to one another. Whilst some specifically target aspects of health, such as developmental health (Shimada et al., 2004), others claim to study health by only assessing a few health variables. Table 6 highlights the differences between five random sample studies of health in various parts of the world. Each has used their own methods for determining health. Within this sample, the only attribute that is common for all is cribra orbitalia and none have considered stature to be an important variable. The sites of Vallerano and Alepotrypa have both been interpreted as having poor childhood health and good dental health (Papathanasiou, 2005, Cucina et al., 2006). Are they comparable? Is it scientifically valid to compare any sites that are interpreted using different methods? Kjellstrom et al. (2005) has argued that an effective comparison of overall health between sites or regions is difficult.

It has also been argued that comparison of the same health variable is problematic. For example, there have been numerous studies that have concentrated on dental caries as an indicator of nutritional health. Wesolowski (2006) reviewed 26 of these studies published in journal articles and book sections between 1999 and 2003. The level of methodological reporting was diverse and Wesolowski (2006) argues that this is a dilemma and comparative studies can be erroneous. What one bioanthropologist identifies as caries may differ from another bioanthropologist.

In the early 1990's a seminal paper was published that placed doubt on all health assessments made from skeletal materials from archaeological sites. The concept of the 'Osteological Paradox' was introduced by Wood et al. (1992). It prompted a reassessment of the interpretation of health within the biological anthropology discipline (Wood et al., 1992). Wood et al. (1992) state that in health interpretation, there is an assumption that there is a direct relationship between skeletal markers and associated risks, and that this is incorrect. In addition, it is argued that there are three concepts that are not addressed. These three concepts are:

1. Demographic non-stationarity - a population is not static and is variable.
2. Selective mortality - bioanthropologists cannot determine how many people were at risk

of death at any one time, just those who died.

3. Hidden heterogeneity - a group of individuals from a population has varied susceptibility to conditions, and therefore has different frailty. The source of the frailty may be, for example, genetic or socioeconomic.

Table 6: Comparison of a sample of health status studies.

	VALLERANO[6]	ALEPOTRYPA[7]	MALIBU[8]	MURRAY BLACK COLLECTION[9]	HOKKAIDO[10]
Enamel Hypoplasia	✓	✓		✓	✓
Porotic Hyperostosis		✓			
Cribra Orbitalia	✓	✓	✓	✓	✓
Caries	✓	✓	✓		✓
Alveolar Bone Defects	✓	✓	✓		✓
Stature					
Harris Lines				✓	
AMTL	✓		✓		✓
Periostitis		✓	✓	✓	
Joint Disease		✓	✓	✓	
Trauma		✓	✓	✓	
Congenital Pathologies				✓	
Paleodemography		✓	✓		

[6] CUCINA, A., VARGIU, R., MANCINELLI, D., RICCI, R., SANTADREA, E., CATALANO, P. & COPPA, A. 2006. The Necropolis of Vallerano (Rome, 2nd–3rd Century A.D.): An Anthropological Perspective on the Ancient Romans in the Suburbium. *International Journal of Osteoarchaeology,* 16**,** 104-117.
[7] PAPATHANASIOU, A. 2005. Health Status of the Neolithic Population of Alepotrypa Cave, Greece. *American Journal of Physical Anthropology,* 126**,** 377-390.
[8] WALKER, P.L., DRAYER, F.J. & SIEFKIN, S.K. 1996. Malibu Human Skeletal Remains: A Bioarchaeological Analysis. Sacramento: Resource Management Divisions, Department of Parks and Recreation.
[9] WEBB, S. 1995. *Palaeopathology of Aboriginal Australians,* Cambridge, Cambridge University Press.
[10] OXENHAM, M.F. & MATSAMURA, H. 2007. Oral and Physiological Paleohealth in Cold Adapted Peoples: Northeast Asia, Hokkaido. *American Journal of Physical Anthropology,* 135**,** 64-74.

Due to the three concepts, Wood et al. (1992) argue that health interpretation based on skeletal data are not feasible. Other researchers, such as Goodman (1993) admit that a paradox does exist, but disagree with the severity implied by Wood et al. (1992). Wood et al. (1992) state that an individual with good overall health may have a skeleton with numerous healed lesions. They argue that, as the individual survived a disease, they were healthy enough to fight the disease and died much later than the manifestation of the disease. Whereas an individual with no lesions may actually be unhealthy as the individual may have had the same condition, died as a result of the condition, and never had the opportunity for the disease to manifest in the bones, despite the fact that we may never know if they even suffered any conditions. Goodman (1993) argues that Wood et al. (1992) do not understand the basics of paleoepidemology, as they focus on cause of death and use single indicators, rather than multiple indicators and the skeleton as a whole. Goodman argues that the concept of selective mortality and its implications is incorrect and an oversimplification. Most indicators are lesions and, as such, indicate that the individual survived for a long time after the event. An example Goodman (1993) presents is that on their own, stature and enamel hypoplasia as health variables do not give an understanding of the health of an individual, but together they provide complementary information. Goodman (1993) also criticizes Wood et al. (1992) for not understanding the impact of other factors, such as cultural context. Goodman emphasizes the importance of understanding the biological process holistically. Despite this, a key result of the publication of the article by Wood et al. (1992) has prompted researchers to reassess assumptions and interpretations made from bioarchaeological data (Wright and Yoder, 2003).

The problems associated with comparative studies underscore the need to develop consistent and comparable methods to determine health status. The Osteological Paradox highlights the need for wide-ranging health variables and context to be utilized in health interpretation. Researchers have pursued the regulation of health interpretation by developing recording standards (Buikstra and Ubelaker, 1994) and a standardized health index (Steckel et al., 2002b), which is reviewed below.

3.2 Health Index Models

3.2.1 What is a health index?

Health indices have been used in the medical field to understand public health since the 1970s (Boyle and Torrance, 1984). The purpose of a medical index is to enable easy comparison of the biological quality of life between individuals or groups. An individual or group is given a single number that enumerates their health based on a number of attributes (Figure 9).

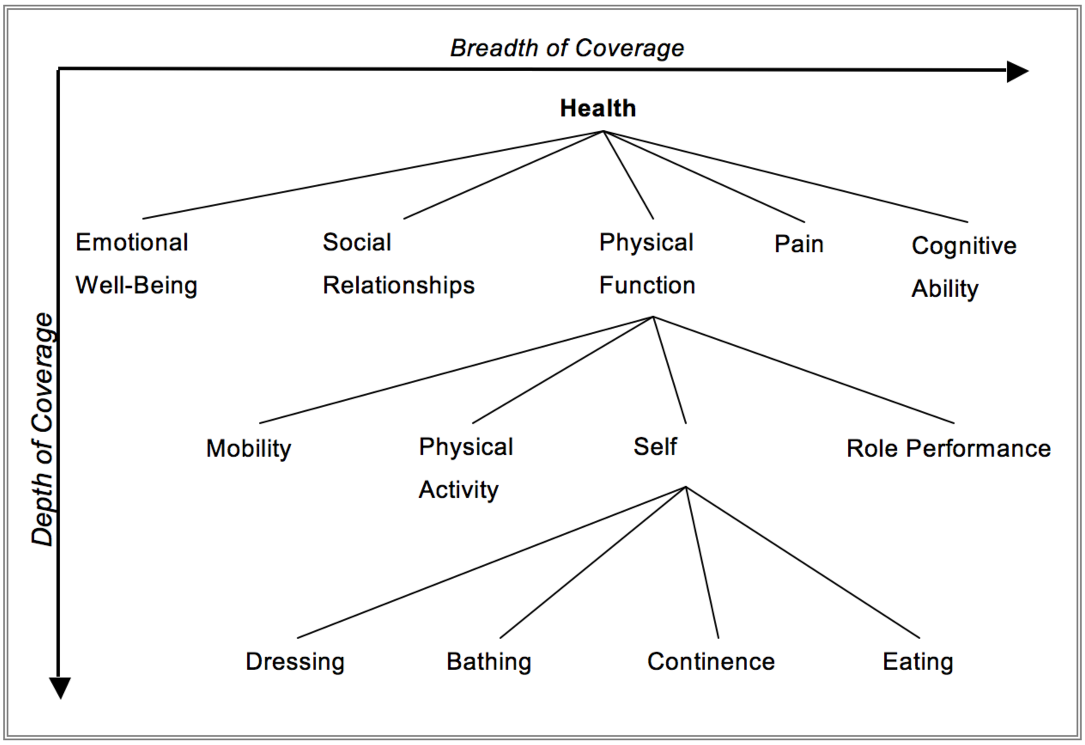

Figure 9: Model for a medical health index, modified from Boyle and Torrance (1984).

Comparative medical health studies rely on data that they receive from patients. There are numerous attributes and combinations. For example, one attribute could be pain, and the five possible responses could be "no pain", "some mild pain", "some severe pain", "chronic mild pain", or "chronic severe pain". Another attribute may be emotion, where the response is either "happy" or "sad". There are eight possible combinations in this simple example. More complex evaluations could have combinations that number in the thousands. The development of health indices enables these combinations to be numerated into a single figure and be placed within a comparable database.

3.2.2 Health Indices for Archaeological Contexts

The 1990s (Steckel, 2002) saw the development of a health index and the suggestion that it could be used in archaeological contexts . The use of a health index was not suggested by physical anthropologists, but by economists whose research interests included archaeological sites. Richard Steckel, an economist from Ohio State University argues that bioanthropologists "usually lack the broad perspective of social scientists interested in larger environmental processes that shape community health, much less long-term historical forces that affect the rise or fall of civilizations" (Steckel, 2005: 3). As a social scientist, Steckel (2005: 3) states that bioanthropology is seen as a "discredited pseudoscientific research" and that "Most social scientists still must be persuaded that the subject is useful." He does, however, believe that skeletal remains can "...provide a more extensive and complete picture of community health..."

(Steckel, 2005: 4). With this in mind, Steckel proposed the production of a health index to be used in conjunction with multi-disciplinary information, including archaeological and environmental data: the Western Hemisphere Health Index.

3.2.2.1 Western Hemisphere Health Index

The health index developed for the Western Hemisphere Project was published in 2002 (Steckel and Rose, 2002). Although, it is based upon modern medical health indices, the range of medical data are not available in archaeological contexts. Unknown factors include comprehensive data on a person's health from birth to death, life expectancy and average population height. In spite of this, Steckel et al. (2002) has endeavoured to produce a preliminary health index, which can be modified and refined.

The index uses the concept of Quality-Adjusted Life-Years[11] (QALY), as well as a set of assumptions, as the basis for the calculation of the health index score. The index attempts to assess the entire life of an individual, and the quality of life of that individual. To calculate QALY, there needs to be a life table of the population (life expectancy calculation) and age-specific estimates of the well-being of the population (U.S. Department of Health and Human Services, 1991). Well-being includes mental, physical and social functioning. "By multiplying the measure of well-being by the number years of life remaining at each age interval, an estimate of the years of healthy life for a population can be derived" (U.S. Department of Health and Human Services, 1991: 445). For example, a person who lives to 75 years may have had only 62 quality life years. Within a health index based on individuals from an archaeological context, well-being is calculated using data obtained from the skeleton that informs on physical well-being. Social and mental well-being cannot be identified.

As researchers cannot know the exact health history of an individual recovered in an archaeological context, skeletal indicators are used. The indicators that are used in the Western Hemisphere Health Index are stature (related to modern genetic potentials); hypoplasias; porotic hyperostosis; dental health (caries, ante-mortem loss and periapical cavities); infections; degenerative joint disease; and trauma (Steckel et al., 2002b). All of these pathologies are weighted equally and scored on a scale of 0 to 100 percent for each individual.

Whilst all of these indicators may be used for adult skeletons, not all are suitable for sub-adults. In the Western Hemisphere Health Index all individuals under 18 are considered sub-adults. For example, stature is excluded from sub-adult index calculations, as there are no methods to

[11] Also known as 'years of healthy life' U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES 1991. *Healthy People 2000 : National Health Promotion and Disease Prevention Objectives,* Conference ed., U.S. Department of Health and Human Services, Public Health Service.

accurately predict projected adult stature. Joint and dental diseases are also not recorded for sub-adults as it is assumed that these conditions did not exist prior to adulthood. The calculations for adults are also affected by assumptions. The years before 18 are not included in the calculation of well-being in joint and dental diseases, and it is assumed that joint and dental disease as well as trauma and infections only impacted on 10 years of a person's life.

In the Western Hemisphere Health Index, there is a nominal data range of health. The score that an individual can obtain ranges between 0 and 100, with health being rated as excellent (100), moderate (50) and death (0). Whilst the individuals, being skeletons, that are being scored are all dead, these scores are presumably calculated to represent the lifetime of an individual. An example given by Steckel et al. (2002b) is that a person lived only for 40 years who had moderate health status obtains an index score of 20. Figure 10 shows an individual who had poor health in childhood, had better quality health in late adolescence and adulthood, but whose health declined in their 30s and died age 40. The area under the curve below *Q* is the biological quality of life measure.

Whilst the basis of any health index is at an individual level, which then can be then used to construct groups or populations, the Western Hemisphere Health Index can only be used at a population level. The purpose of the production of the Western Hemisphere Health Index is to compare different archaeological sites. All skeletal material is included in the health index. Skeletal material may consist of individuals represented by only one bone or tooth to those with a complete skeleton. An individual that is represented by only one or two bones cannot be individually assessed for health. Where quality has been compromised, as in this situation, only group or population health can be assessed. This methodology consequentially loses the intricacies of a population's health.

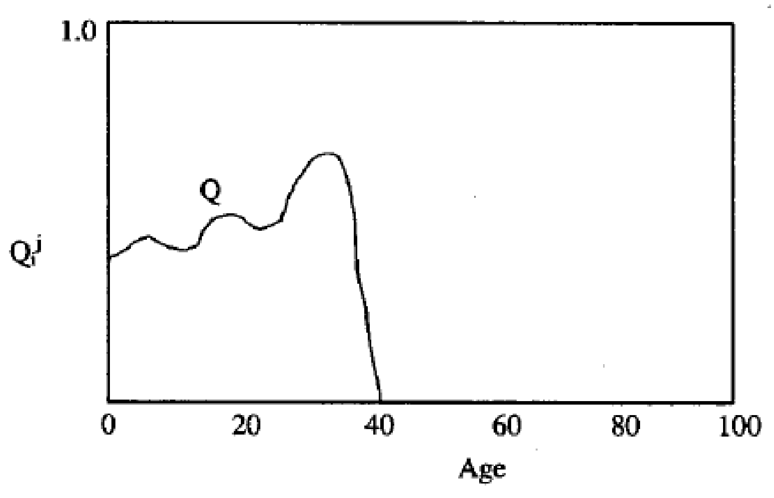

Figure 10: Graphic representation of biological quality of life at each age (from Steckel et al., 2002b: 64).

In order to calculate the QALY in the Western Hemisphere Health Index, the archaeological samples needed to be compared to an 'ideal' population that has some similarity in mortality patterns to the archaeological sample. The Western Hemisphere Project covers a wide range of groups, eras and environments and, in essence, could not have a single reference group that would cover them all. As a result, they chose a life expectancy reference group, based on the Model West Level 4 Life Table devised by Coale and Demeny (1983 cited in Steckel et al., 2002b). This is a synthetic population with a life expectancy of 26.4 years and a growth rate of 0 percent.

With measures of well-being (skeletal attributes) and a life expectancy estimate, the calculations for QALY seen in the Western Hemisphere Health Index involved the following:

- Sum of each skeletal attribute.
- Each attribute sum is multiplied by an age specific rate by person years lived in each age category[12] of the reference group.
- Each of these numbers are summed and divided by the life expectancy of the reference group (26.4 years). The numbers obtained for each attribute is a percentage of the maximum attainable.
- All of the attribute percentages are averaged and then multiplied by the life expectancy of the reference group (26.4 years). The figure finally obtained estimates quality-adjusted life-years.

Each group under study was then placed on the index as a percentage of that maximum (26.4) and comparisons between groups could be made.

The Western Hemisphere Health Index was tested within the Western Hemisphere Project (Steckel et al., 2002b, Steckel et al., 2002a). They obtained data from numerous eras, locations within North and South America, different ethnic groups and societies. The information imparted inferences beyond simple statements and ranking of health. For example, temporal and locational variations could be seen: health declined from mobile to sedentary lifestyles; a decrease in health was evident when domesticated plants became common and an increase in health was also evident for coastal populations as well as those located below an elevation of 300 metres.

The health index has been tested by other researchers (Kjellström et al., 2005, Wentz, 2006, Molnar and Kjellström, 2008). Kjellström et al. (2005) used the health index on a number of cemeteries in Sweden. They followed the guidelines of Steckel et al. (2002b) using all of the

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[12] Age categories in the Western Hemisphere Health Index are 0-4, 5-14, 15-24, 25-34, 35-44 and 45+

recommended indicators, and then calculated quality of life based on all sites, temporal phases, sex and individual sites. The Model West Life 4 table was used as the reference population. Whilst they thought that their sample may have been too small for inter-site comparisons, patterns in temporal phases and other contexts could be identified. For example, deterioration in health or quality of life could be identified. Later, Molnar and Kjellström (2008) compared a hunter-gatherer population and a medieval farming population in Sweden. Overall health appeared better in the hunter-gatherer population. They were able to identify where the populations differed within the health attributes, which assisted in the interpretation of overall health.

Wentz (2006) utilised the Western Hemisphere Health Index to analyse population health at the hunter-gatherer Amerindian site of Windover. Based on the health index score, Wentz (2006) found that the health was uncharacteristically poor for a hunter-gatherer population. It is suspected that this may be the result of nutritional, environmental or social crises and possibly a transition from hunter-gatherer to an agricultural and sedentary lifestyle. Wentz did have difficulties using the Western Hemisphere Health Index and this is discussed in Chapter 3.2.4.

While Steckel et al. (2002b) acknowledges that the health index is a crude tool, it can be refined. The index has the ability to analyse numerous aspects; for example where sex can be identified in individuals, they can be placed within sub-groups. In theory, a large sample is capable of engendering a range of different scenarios.

3.2.3 Limitations of any prehistorical health study

The application of a health index is not without difficulties, but many of these are common in most archaeological-based health studies (Steckel et al., 2002b). Only some chronic conditions are visible on the skeleton. It may appear that the individual was healthier than they were, as stated in the Osteological Paradox (see Chapter 3.1). Acute diseases may result in either a quick recovery or death, which either way, it is argued, would have minimal impact on an individual's skeletal health index score. There are other potential life-threatening problems that may not be visible in the skeletal record, such as blindness, and emotional stress. Without a detailed historical medical record, these types of conditions will never be known.

Whilst the skeleton can provide signs of a disease, it cannot not always indicate the duration of the condition or level of impairment. Currently, paleopathologists are able to identify lesion patterns on bones that they may be able to directly relate to a specific disease, such as leprosy. In most cases, however, the condition can only be identified as non-specific. As more experimental and pathological research takes place, such as the study of the effect of specific diseases on the skeleton in modern populations, further knowledge on duration and impairment will become known.

All populations are subject to selective or seasonal migrations. Researchers in the study of prehistoric people cannot assume that the population is static and genetically homogenous. Genetic heterogeneity may occur, and can result in variation in health between individuals (K. Domett and N. Tayles, 2006). The only way to test homogeneity is to look for familial connection through bone chemistry analysis and DNA testing. This is beyond the capabilities, time and funding of most archaeological projects.

Sampling bias has the potential to greatly impact on archaeological interpretation. Excavation methodology relies on sampling strategy. It is rare to completely excavate an entire site. Many archaeological sites are large and may cover many hectares. Excavation of such large areas is normally financially unviable and projects are subject to time constraints. Archaeologists employ a sampling strategy that will provide a suitable amount of information to provide an interpretation of the site. Various methods include placement of random trenches, excavating the highest point, or excavating the area of greatest surface finds. The difficulty of these sampling strategies is that, with regard to cemeteries, there may be differential burial placement. For example, there may be a society whose burial rituals separated children from adults, isolating children on the outskirts of a cemetery. If the excavation trench only encountered adults, or only children, the interpretation of the site and the health of the population would be biased. If no children were found, what would the interpretation of the site and the health of the inhabitants be? The sites that have a larger proportion of their area excavated will have a more reliable interpretation but even so, smaller sampling strategies are still valid. The aim is to provide an indication of the society, and sampling a small area does provide an indication. No amount of excavation will uncover the mechanisms of a society with any certainty; it can only contribute to interpretations of material evidence.

Taphonomic processes impact on the ability to process and interpret material evidence. Traditionally, taphonomy is the study of the transition of organic materials from the ecosystem to the geological record (Lyman, 1994). This concept has been adapted for use in the archaeological field to study what happens to material remains, including corpses, from the time of deposition to the time they are recovered. Differential preservation of materials and post-depositional interference can result in an incomplete skeletal record. In the assessment of all skeletal indicators, the preservation of bones found in a burial context is of paramount concern. Not all bone survives the burial process. Bone preservation can vary amongst individuals in a sample and spatially across a site, depending on taphonomic processes.

The taphonomic factors that affect archaeological collections can be identified as being either uncontrolled or controlled (Mays, 1998). These factors can be shown in a flow diagram (Figure 11) devised by Mays (1998). They show the numerous biases inherent in archaeology, focusing on post-mortem, pre-burial, burial and post-burial aspects. Descriptively they explain what happens to human remains at all stages following death, which can vary from insect interference, root etching, corpse exposure, deliberate defleshing, and cremation to agricultural interference. One example was seen in the site of Ban Non Wat in Thailand during the 2005/6 excavations. Small, perfectly circular holes were found in human bone. These holes are not culturally made drill holes or pathological lesions, but the bore holes of insect larvae, as seen in Ortner (2003: Figure 4-1). Taphonomic processes are dynamic and include a range and varied combination of natural and cultural processes.

Excavation and recovery strategy are the main controllable biases. How, and by whom, the burials are recovered is important. Inexperienced excavators may not recognise small bones, especially if the burial fill is not sieved. As stated above, it is generally not possible to excavate an entire cemetery. For a viable comparable sample, it must be demonstrated that it is representative of the cemetery and the population as a whole. This forms part of an uncontrollable factor, as burial practices may differ within a society. Other uncontrollable factors include the soil chemistry, acidity, temperature and porosity, which have an irreversible impact on the survivability of bone (Mays, 1998, White and Folkens, 2000). Leaching of bone minerals into the surrounding soil matrix can make the bone more fragile (Lyman, 1994).

The impact of bone sample bias has been investigated by Bello et al. (2006) who studied three types of interments: mass grave; burial ground cemetery; and vault burials. They found that the burial ground cemetery was the least preserved or represented, probably due to agricultural practices, roots and soil acidity. They concluded that taphonomic processes do not act uniformly on burials. In addition, there has been some research to quantify the variables of taphonomic disturbance in order to understand their impacts (Lieverse et al., 2006). This quantification would be useful in understanding burials, especially where there is gross disarticulation.

Whilst there are numerous problems associated with the analysis and interpretation of past societies, there are also methods to assist in counter-acting them. Missing bones are inevitable due to taphonomic processes. Inadequate sample sizes, referring to number of individuals, which may lack many of the skeletal components used to estimate age and sex, is problematic. Where there is differential bone preservation, a multiple variable assessment becomes invaluable. For example, in sex determination, where there are no pelvic indicators, then the skeletal indicators on the skull can be used. The more indicators used to sex an individual, the better the degree of success.

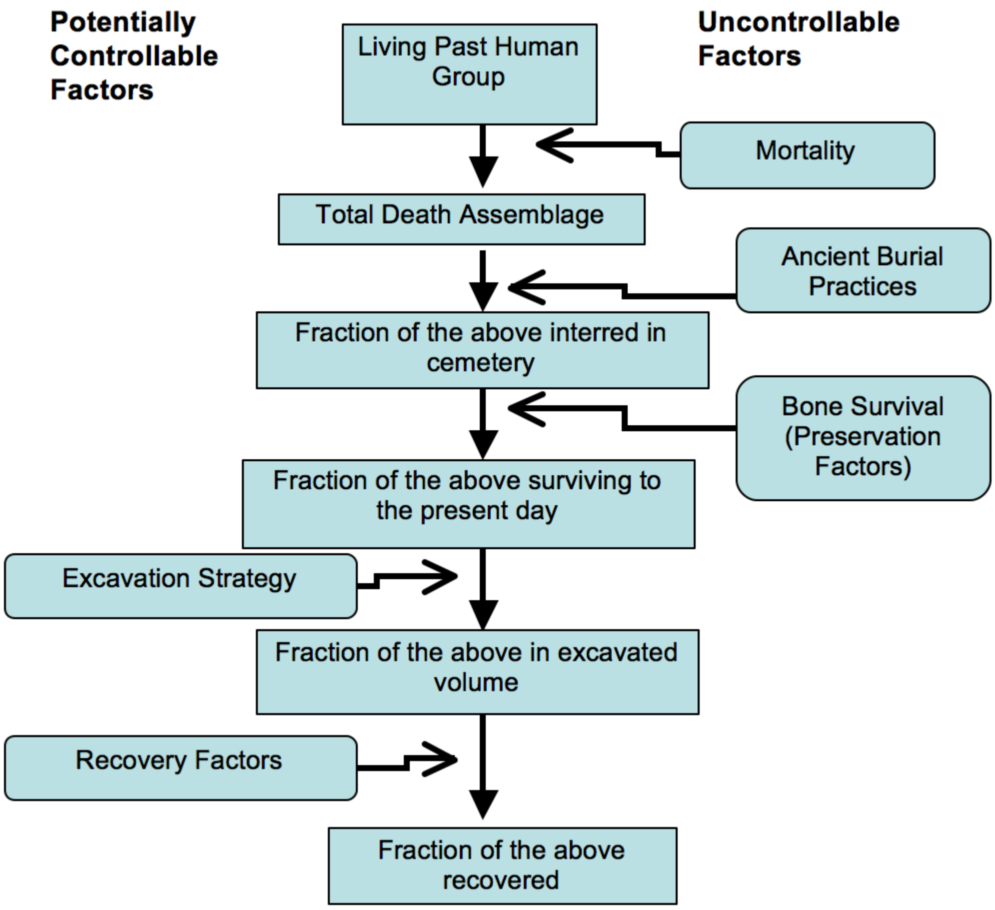

Figure 11. Taphonomic factors that affect archaeological skeletal collections (from Mays, 1998).

All of the factors discussed above are problematic in any archaeological study. Methodologically, there are ways of offsetting some of these problems. Essentially, the archaeological study of human remains is an interpretative exercise. No matter the size of the sample or what tapohonomic processes it has undergone, the skeletal remains comprise the only data that we have on past biological societies. Bioarchaeologists can only analyse the materials and evidence that is present, in whatever form. Our links to prehistory have been severed, and bioarchaeological interpretations of health and society are important factors in our understanding of the past.

3.2.4 Limitations of the Western Hemisphere Health Index

There are limitations that are specific to the Western Hemisphere Health Index (Steckel et al., 2002b). These include assumptions inherent in the methodology; it uses problematic life-expectancy models; and it is a blind calculation. These issues are discussed in this chapter.

The Western Hemisphere Health Index consists of a number of assumptions. One such assumption is that a chronic condition, including dental disease, infections, joint disease and trauma, was present for only 10 years before death. This is an arbitrary figure chosen by the authors, which they admit is not ideal, as the period of the condition would depend on numerous factors. They argue that to calculate a score for the index, a set number of years for a condition are required. As stated in Chapter 3.2.3, the duration of a condition cannot be estimated. Steckel et al. (2002b) argue that a consistency in assessment methodology and averaging of data would nullify errors relating to this.

The assumption of 10 years for a chronic condition also brings up practical difficulties. It is especially problematic if the condition is non-specific, particularly if a skeleton has numerous lesions that cannot be attributed to a particular disease. If a skeleton has three lesions, will those lesions be assumed to be concurrently formed and only 10 years is assumed or will they be considered to have taken place at different times, and therefore a maximum of 30 years is assumed? How the developers of the Western Hemisphere Health Index have dealt with this issue is unknown due to the lack of transparency in the calculation of the score.

The Model West Level 4 Life Table was used by Steckel et al. (2002b). Life tables are used in paleodemography, which is the study of patterns of mortality, fertility, estimates of distribution, intensity and age composition. They have been used in bioarchaeology to identify population representativeness and estimate population size and expected distribution of age and sex in cemeteries (Gibbon, 1984). It has been used by some researchers to investigate mortality and known events, such as the Black Death Plague of Europe in the 1300s (Gowland and Chamberlain, 2005). By looking at age profiles at death, Gowland and Chamberlain (2005) suggest that statistical methods can be used to identify catastrophic events in prehistory.

The application of life-tables in prehistoric bioarchaeological studies has its critics (Bouquet-Appe and Masset, 1982, Buikstra and Konigsberg, 1985). It is vulnerable to sampling error within the reference population. In order to conduct a paleodemographic study using reference populations, an unbiased and representative sample is required. It has been found that paleopopulations vary from reference populations, especially if the reference population is not represented by all age groups. Despite this, it has been argued that valuable information can be gained using paleodemographic analysis (Alesan et al., 1999).

Modern life-expectancy models are used in the calculation of the Western Hemisphere Health Index score. The Model West Level 4 Life Table was used by Steckel et al. (2002b). They are based on a number of assumptions (Alesan et al., 1999). These include that it has an accurate age-at-death structure and that the population is static. Alesan et al. (1999) constructed a life table based on an archaeological sample and compared it to other life tables, like that of Coale and Demeny (1983 cited in Steckel et al., 2002b), and found that synthetic reference population life tables are problematic. Patterns of mortality vary between populations and as a result, life tables used may not be appropriate (Gage, 1988). It has also been argued that life tables are appropriate in prehistoric studies. Nagaoka et al. (2006) argue that ancient populations most likely had zero growth rates and stable mortality rates. However, the various studies of prehistoric populations throughout the world have shown variability in these rates[13]. There are numerous issues with the use of life tables, as stated above and especially in Southeast Asia where there is limited data. It may be more appropriate to develop a health index that does not incorporate them.

Few researchers have tested the Western Hemisphere Health Index outside of the Western Hemisphere Project. The Amerindian sample from the prehistoric site of Windover provided a practical examination of the Western Hemisphere Health Index (Wentz, 2006). Whilst Wentz argues that some of the attributes are not as comprehensive in recording pathologies, especially the trauma attribute, the method of recording assists in minimizing inter-observer error due to its simplistic nature. Notably, this is seen in the "absence/presence" scoring of many attributes. For example, degenerative joint disease is recorded as either absent or present. Based on Wentz's (2006) study there appears to be some value in developing a standard methodology for regional areas, such as a health index designed for the Americas and another for Europe.

Wentz found inconsistencies in the calculation of health index scores. Wentz (2006: 95) states that "The nature of the computer program used to calculate scores for the Western Hemisphere Health Index, although user friendly and accessible is problematic due to the "black box" nature of the software."

The Western Hemisphere Health Index is still a blind calculation and confidence in the results may be an issue. Wentz (2006) found an error in the data and re-sent the corrected data to be analysed. Rather than the associated attribute score being changed, another attribute was altered. This resulted in "a scores change in the absence of new data" (Wentz, 2006: 95). It is difficult to trust the results of the health index analysis as a result.

As Steckel et al. (2002b) admit, the Western Hemisphere Health Index is a crude tool that can only benefit from refinement. It is the purpose of this study to understand the problems involved with the Western Hemisphere Health Index and use this knowledge to develop a health index that not only can be used in Southeast Asia, but is adaptable for use on a global scale.

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[13] For example, compare paleodemographic analysis of Non Nok Tha (DOUGLAS, M.T. 1996b. *Paleopathology in Human Skeletal Remains from the Pre-Metal, Bronze and Iron Ages, Northeastern Thailand.* PhD, University of Hawaii.) and Ban Lum Khao (DOMETT, K. 2004. The People of Ban Lum Khao. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department, 113-158.).

4 SOUTHEAST ASIAN HEALTH INDEX

4.1 Framework of the Southeast Asian Health Index

The development of the Southeast Asian Health Index (SEAHI) was inspired by the Western Hemisphere Health Index (WHHI) (Steckel et al., 2002b). An initial discussion on the WHHI is found in Chapter 3.2.2.1. The WHHI has been presented as the first stage towards a consistent and comparable methodology that enables researchers to quantify the life quality and health history of individuals based on the analysis of the human skeleton. The SEAHI has used the WHHI for a basis and has altered some aspects to suit the information available for the Southeast Asian region. Various aspects of the WHHI were considered as being unsuitable for the SEAHI. Such aspects included the use of life tables and age estimates.

4.1.1 Testing of the Health Index

In many ways the SEAHI is a simplification of the WHHI, which enables any researcher to calculate the Index themselves and thus enable a transparent understanding of the treatment of the data. At present, to use the WHHI, investigators have to send their sample data to the WHHI researchers to be calculated. Although simplified, the SEAHI still provides an insight into the health of a past community. The ultimate purpose of a health index is to give an individual a rank, or a status relative to others, within a group of individuals. A simple health index, based on sound principles relating to the types of information obtainable from skeletal material, should have the same outcome as a complex health index. Age has become an attribute, which is now equally weighted and has been modified to reflect the difficulties in aging adults. All of the attributes have equal weight. It would be difficult to justify unequal weighting of attributes with our current understanding of paleopathology since the functional impact of pathologies, as well as a more refined understanding of the aetiology of many lesions, needs to be better understood. Complex computer programs are not needed for the SEAHI. Any researcher with a data manipulation program can use the index.

The SEAHI can examine a sample at an individual level, although not all individuals in a sample can be assessed. Due to the nature of the SEAHI, skeletal samples need to be of adult age and near complete; that is, that the individual burial must contain the majority of elements, especially long bones, skull and teeth. In order for the SEAHI to be viable, the individual has to be able to provide a wide range of information. This can only be provided in an individual that is well represented skeletally. These elements are able to provide information that informs on an individual’s growth, dental health, as well as childhood, joint and chronic disease history. An individual that consists of a few long bones will not be able to provide an adequate number of elements to be able to assess their health history. Whilst this is an imperfect situation and one which may never be rectified, health indices can provide valuable information. Grouping individuals can also provide information about populations and subgroups within that population.

As the SEAHI is based on the WHHI, a similar scoring basis is also used. The range of scores an individual can achieve is between 0 and 100, 0 being of extreme poor health and 100 being of extreme good health. There are eight attributes: age, dental health, stature, enamel hypoplasia, anaemic reactions, trauma; degenerative joint disease and other pathologies. Within these attributes there may also be sub-categories or body element sections, but each attribute alone is scored on the 0-100 scale. After all of the attributes are scored, a combined final score is standardized using z-scores. An individual must have a score from at least six of the eight possible attributes to be able to illustrate an individual's health history. Less than six attributes lessens the reliability of the index and introduces inevitable errors. For example, of the 120 individuals at Noen U-Loke, only 43 skeletons possessed an adequate number of attributes. Whilst this is less than 50 percent of the sample, it is still considered to be a good number due to the poor quality of skeletal remains.

Within this study, where two datasets are used, the methods for recording data for the different attributes inevitably differ. Noen U-Loke was excavated between 1996 and 1998 and analysed in 1999 by various researchers (Tayles et al., 2007). A census of the skeletal elements was taken, age, sex, dental, and descriptive anomalies of joints and bones recorded. The Noen U-Loke databases were examined and those individuals with sufficient number of attributes were chosen and placed in a separate database to enable interpretation for scoring. The Ban Non Wat skeletal sample was excavated from 2002 to 2007. Laboratory recording of census and attribute data took place from 2006 to 2008 by the author. The data collection methodology was structured to enable easier conversion to SEAHI scores, but a descriptive system was still employed rather than one directly linked to the SEAHI scoring system. As the health index was still being developed this enabled alterations and refining of the health index after the data had already been collected. For the Ban Non Wat skeletal collection, sex and age determinations are to be conducted by a single researcher, Nancy Tayles, in order to minimize intra-observer error. As the Ban Non Wat collection consists of 637 burials, Tayles would be unable to age and sex all of the individuals prior to the completion of the laboratory work. Therefore, it was determined that preliminary age and sex determinations made by the author in the laboratory would suffice, with the proviso that in the future, these determinations may change. Further details of these determinations are discussed below. The following is a description of the methodology followed for the SEAHI.

4.1.2 The dataset

4.1.2.1 Ban Non Wat - Skeletal Material

Skeletal material from Ban Non Wat was cleaned using dental picks, small metal spatulas and brushes. Cleaning of the skeletal material was conducted by the author with assistance from Anna Willis, Diana Leech, Kimberley Curtis, Rachanie Thosarat, Lynley Wallis, Kaew, Daeng and Aoul. Some bone elements were reconstructed using PVA glue. Recording of all data was conducted by the author.

A sample of the excavated skeletons from Ban Non Wat were selected. The majority of Bronze Age skeletons were in good condition. The Iron Age skeletons, however, were of poorer quality in general. Calcretions were found adhered to many skeletons. In many cases the calcretions could not be removed. Partial success was possible using an acid solution to dissolve or weaken the calcretions. This consisted of a 5% solution of acetic acid, phosphate buffer (Na_2HPO_4) and distilled water. Table A 25 (p. 448) provides a pathological condition summary of each individual examined in the sample from Ban Non Wat. This table attempts to show the non-quantifiable health of each individual.

4.1.2.2 Noen U-Loke – Skeletal Material

The Noen U-Loke skeletal material was cleaned manually using dental picks and brushes by Nancy Tayles and Natthamon Pureepatpong, with robust bone also being washed with water (Tayles et al., 2007). Reconstruction of some bone was conducted using PVC glue (Tayles et al., 2007: 245). Bone preservation was variable, with some bone being highly demineralised as a result of burial practices. In some cases the body has been buried on top of unthreshed rice, which was highly destructive to the bone. Recording of census, dental and pathological indicators was conducted by various researchers, including Nancy Tayles, Kirsten Nelsen and Natthamon Pureepatpong.

4.1.3 Components of a Southeast Asian Health Index

In order for this study to be comparable with other sites and regions within Southeast Asia, an index similar to that devised by Steckel et al. (2002b) is required. The skeletal indicators chosen for the Western Hemisphere Project are commonly used in many skeletal studies, and are easily used and understood (Goodman and Martin, 2002). Each indicator provides unique information relating to childhood and adult health.

The indicators that are used in the Southeast Asian Health Index are:

1. Age at Death
2. Dental Health
3. Trauma
4. Long Bone Lengths
5. Enamel Hypoplasia
6. Degenerative Joint Disease
7. Childhood Orbital/Cranial Lesions
8. Infections/Other Pathologies

In addition, demographic data and prevalence of conditions are presented in a standard form prior to the same data being incorporated into the Southeast Asian Health Index.

4.1.4 Age at Death

Estimating the age at death of skeletal remains in archaeological contexts is one of the most important skeletal assessments. It provides the basis for understanding the individual and their health. Age estimation is difficult as, biologically, skeletons of individuals do not age alike and not all components of the skeleton survive in an archaeological context. Aykroyd et al. (1999: 57) explains :

> "Once all the bones of the skeleton have developed and all the teeth have erupted the body will start to degenerate but the degeneration will not occur at the same rate for everybody; disease, diet and physical activity, for example, may affect how fast or slow a body (and its skeleton) ages."

Many factors affect the skeleton and therefore the aging process, including disease, nutrition, trauma as well as environmental and cultural factors (Falys et al., 2006). A number of methods have been developed to age sub-adults and adults. Sub-adults are not included in this study; therefore, aging methods for sub-adults will not be discussed here. There are numerous methods to age adults, both macroscopic and microscopic and those that are relevant to the present study are discussed below.

4.1.4.1 Methods

Pubic symphysis morphology, as an indicator of biological age, has been studied by numerous researchers (including Gilbert and McKern, 1973, Suchey and Katz, 1986, Al-Salihi et al., 2002). The surface of the pubic symphysis changes with age. During adulthood, the face of the pubic symphysis alters from billowing with ridges and furrows to being eroded smooth with pitting. A number of scoring systems have been developed based on these changes. Todd developed a 10 phase aging system method in the 1920s (cited in Brothwell, 1981, Al-Salihi et al., 2002) then in the 1950s this method was altered and five phases were identified for males (McKern and Stewart 1957 in Gilbert and McKern, 1973). It was recognised that males and females differed in the morphology of the pubis symphysis, particularly in the area of the ventral rampart (Gilbert and McKern, 1973). Gilbert and McKern (1973) devised a system for female aging, but recognized that there was a high standard deviation. The method was further modified into a six phase system, with a separate morphological sequence for males and females (Suchey and Katz, 1986). This methodology is now referred to as the Suchey-Brooks Method. Al-Salihi et al. (Al-Salihi et al., 2002) examined the four methods: Todd, McKern-Stewart, Gilbert-McKern and Suchey-Brooks. The sample used was small (17 males and 11 females), but were modern cadavers and had known ages. All of the methods underestimated age, but the Todd and Suchey-Brooks systems had a high correlation in age determination, despite underestimating female ages.

Another method of aging individuals is by examining the teeth for attrition: wear on teeth, mainly using the molars (Miles, 1963a, Brothwell, 1981, Lovejoy et al., 1985a, Walker et al., 1991, Mays et al., 1995, Miles, 2001). Modern diets are predominantly composed of soft processed foods, but the diet of pre-industrial populations used to be quite gritty. Wear on the teeth was more common than today. Whilst many aspects of bioarchaeology can be tested by looking at a known population (Kieser et al., 1983), dental wear rates cannot be accurately identified from modern studies due to the differing diet of modern as opposed to ancient populations (Walker et al., 1991). Wear rates may also differ between geographical populations depending on the differing diets.

A method for identifying age rates from wear was developed on European samples (Miles, 1963a, Miles, 1963b). Called the Miles Method, it is based on wear rates in sub-adults, as sub-adults can be accurately aged. It assumes that wear rates are the same for all molars. Miles (2001) recognised that the method underestimated age and was flawed. Lovejoy et al. (1985a) found that the use of seriation or a wear gradient made this method more reliable. Numerous sub-adults are required in a sample to identify wear rates as well as differences between male and female wear rates (Walker et al., 1991). Care needs to be taken as molars within an individual also wear at different rates (Mays et al., 1995). In addition, there needs to be an in-depth understanding of the diet and cultural practices that may affect wear rates. As the wear rates can be population specific, this method can be used in archaeological contexts, and is being used more often in Asian samples where skeletal preservation is not good (Tayles et al., 2007). Where a seriation of wear patterns is not possible, the general identification of age, broadly young as opposed to old individuals can be determined based on the degree of wear. It is recognised that this is a subjective methodology.

The final stage of adult maturation comprises skeletal maturation when bone and epiphysis fusion is completed sequentially (Scheuer and Black, 2000). This begins, in sequence, with the iliac crest (10 to 19 years), spheno-occipital synchrondosis (end of adolescent growth between 11 and 18 depending on sex),medial clavicle (16 to 30 years), ventral rings of the vertebrae (fusion by age of 25 years), and petroexoccipital articulation (from 30 to 50 years) (Scheuer et al., 2008). General age range can be inferred using this method.

Morphological changes to relatively immovable joints, such as cranial sutures, have been tested against age at death (Perizonius, 1984, Meindl and Lovejoy, 1985). The bones of the cranium interlock at immovable joints, known as sutures. As a person ages, these sutures join and then finally fuse together. Early investigations of cranial suture closure patterns on known age samples were conducted by Todd and Lyon (1924 cited in Meindl and Lovejoy, 1985). Later, Meindl and Lovejoy (1985) devised a new scoring method of cranial suture closure, requiring examination of a number of points on the crania. They found that there were sex and population differences in suture closure timing. Perizonius (1984) tested the five stage methodology developed by Acsádi and Nemeskéri in 1970, but found no correlation between age and suture closure for adults over 50 years of age. Cox (2000) states that the processes behind cranial sutures are not well understood, as not all sutures will close in all individuals, and females normally have closure after that of males.

4.1.4.2 Evaluation of aging methods on Asian samples

The methodologies based on morphological change and dentition are population dependent; therefore, how these methodologies have performed in relation to Asian samples is important. Most standards for age estimation are based on Western populations. Schmitt (2004) looked at two forms of age estimation on a known age, modern Thai sample: the Suchey-Brooks pubic symphysis method and Lovejoy et al. (1985b) auricular surface method. The majority of the Thai sample was over 40 years of age. As previously stated, the Suchey-Brooks method underages individuals, especially for females and those over 60, which was also the case in the Thai study. The auricular surface study found that left and right surfaces differed, which has the potential for different age determinations. Only seven percent could be accurately aged (Schmitt, 2004). The auricular surface method also underaged individuals.

The first rib morphology methodology was tested using a Thai sample (Schmitt and Murail, 2003). Schmitt and Murail (2003) found that only 55 percent of the Thai sample was correctly aged using this technique and those aged over 60 were under-estimated. They also found the methodology difficult to use. They conclude that the results may be indicative of morphological variables, methodological difficulties or differences between Asian and American rib morphology. In addition, Halcrow et al. (2007) investigated the use of dental formation data from non-Southeast Asian sub-adult populations to produce age estimates for prehistoric Southeast Asian sub-adults. The results of that study and the tests on Thai samples show that accurate age estimations using macroscopic methods is problematic. Until these methods are refined and population based, imprecise age estimates will continue.

4.1.4.3 Age determination methods in current study

Many researchers use multifactorial methods to age individuals. The most common aging methods are pubic symphyseal morphology and degrees of dental wear. These two methods will be implemented in this study. Other indicators, such as epiphyseal fusion of long bones will also be used. The result will only allow age ranges to be determined; for example, young adult, mature adult and elderly adult. This multifactorial method of pubic symphyseal morphology, dental attrition and epiphyseal fusion was used on both of the skeletal samples from Ban Non Wat and Noen U-Loke, and as a result provides a comparable context.

Ban Non Wat Aging Methods

The age estimation of the Ban Non Wat skeletal sample in this study should be considered preliminary. In order remove intra-observer error, the official age estimates are being conducted by Nancy Tayles. Due to time constraints, Tayles was unable to provide age estimates for this sample; therefore, preliminary age estimates were made from data recorded during field excavation and during skeletal examination for this study. The skeletal material used in this study is only a sample of the entire excavated collection (see Chapter 4.1.2. for further details on preservation and condition of skeletal materials used). For the skeletal sample used in this study, the age of each individual skeleton was determined by examination of:

- general wear patterns on the teeth (based on Smith, 1984)
- pubic symphysis morphology (Suchey-Brooks method as published in Buikstra and Ubelaker, 1994); and
- long bone epiphyseal fusion (Buikstra and Ubelaker, 1994).

The combination of these methods provided a broad preliminary age estimate. The age groups identified were:

- young adult;
- middle aged adult;
- old adult; and
- adult (indeterminate).

In general, a young adult is considered to be between 15 and 30 years; middle aged adult between 30 and 45 years and old adults are over 45 years.

Noen U-Loke Aging Methods

All of the skeletal material excavated at Noen U-Loke underwent an age assessment. Whilst not all of the individual skeletons could be aged due to preservation issues, a majority could be placed into broad age ranges (see Chapter 4.1.2.2. for further details on preservation and condition of skeletal materials used). The age estimates at Noen U-Loke were determined using the following:

- epiphyseal fusion of long bones (Buikstra and Ubelaker, 1994);
- pubic symphysis morphology (Brooks and Suchey as published in Buikstra and Ubelaker, 1994); and
- relative rates of tooth wear (Molnar, 1971).

Age estimates were presented in broad relative age ranges of

- young;
- middle-aged;
- old; and
- indeterminate.

Whilst young adults have been identified as being between 20 and 30, the older adult age range has not been defined (Tayles et al., 2007). The age determinations for this study were based on the raw data provided by Tayles. As with Ban Non Wat, the determinations were based on young adult (c15 – 30 years), mid adult (c30 – 45 years), and older adult (c45+ years).

4.1.4.4 Age Categories

The methods of age estimation are limited. At the present time, methods to accurately estimate the age of mature to old adults are imprecise (Martrille et al., 2007). In order to alleviate the errors at an individual level, a broad view of age must be adopted. Researchers may identify mature adults as being between 25 and 40 or 30 and 40, depending on their methods. The SEAHI utilises age in a different way than the WHHI. How age is used in the WHHI can be described as a denominator that impacts on all health indicators with great complexity.

The WHHI requires a single age estimate for an individual and, as a result, age ranges cannot be used. Due to the difficulties of accurately aging a skeleton, their alternative is to use a mid point in the age range as a score for age. But midpoint estimations do not provide an accurate age estimation either. Age, as a number, is used to calculate age specific scores of the health attributes. To calculate age specific scores of the health attributes, many assumptions are made; for example, that non-childhood pathologies occurred for a duration of 10 years and that only 10 years will be counted with regard to these pathologies. Also dental defects are not counted until the individual is over 30 (Steckel et al., 2002b: 71). In calculating a score for each attribute, the specific age, minus the years where it is assumed that the condition did not exist, is included in that calculation. The score is then compared to a reference population age as a percentage. The reference population age is the life expectancy of a synthetic population based on Model West Life Table 4 (Steckel et al., 2002b: 68). This is a highly confusing method that would involve complex computations. In essence, each score, for example dental pathology, reflects the number of years an individual lived without any pathologies, which is then made into a percentage of the reference population. The reason for this method is that the researchers are hoping to be able to accurately quantify the quality of life of an individual over their entire lifespan.

The problems associated with age estimation and pathology duration are not assisted with the use of complex computations. Therefore, a simpler method can be utilised. Age can be scored in a similar way to that of the other attributes, as age is also an attribute as it is an indicator of death. Whilst errors in aging an individual may still be a part of the index, these would not be exacerbated by any unnecessary computations.

For the skeletal samples of Ban Non Wat and Noen U-Loke, individuals are placed within three categories: young adult (c15 – 30), mid adult (c30 – 45), old adult (c45+). Those that lived longer are given a higher score (Table 19).

4.1.4.5 Results – Age - Ban Non Wat

The following sub-chapter summarises the results of the census assessment for Ban Non Wat. A part of the census assessment determined the sex of the individual. It is generally considered that, in archaeological contexts, a multifactorial analysis of pelvic and skull sex indicators is the best method, with a high accuracy obtainable (Duric et al., 2005). It is also acknowledged that sexual dimorphism is population dependent and that the dimorphism in an Asian population would be different than that of an American or European population on which most methods have been devised (Işcan and Ding, 1995, Işcan and Kedici, 2003, Murphy, 2005).

The indicators for sex using the morphological features identified by Phenice (1969) and also the greater sciatic notch are the most reliable indicators of sex in the pelvis and were used in this study. The skull also has many reliable indicators of sex. As the skull is robust and survives in most archaeological contexts well, it is used to identify the sex of individuals in this study but is secondary to the results obtained from the pelvis assessment. Where an individual could not be sexed from examination of the pelvis or skull, other indicators (based on size) were used. This included a range of measurements, such as the distal tibial width and clavicle length. To determine sex by the clavicle length, for example, the clavicle length of a sub-sample of individuals where there was a confident pelvic sex assessment was used to provide a baseline for placing an indeterminate individual within a sex group. Where the bone condition was poor and fragmentary, a sex assessment was not possible. The methods to sex individuals in Ban Non Wat and Noen U-Loke are the same, which makes the samples directly comparable. The gracile nature of Southeast Asian skeletons was taken into account in the determination of sex using the skull and facial characteristics scale of 1 (gracile/hyperfeminine) to 5 (robust/hypermasculine). Where a score was 3, the individual was considered to be male.

Over 50% of the sample comprises mid aged adults (Figure 12 and Table 7). This is more than double that of the young adult or the older adult sample. The pattern of mid adults dominating the sample is not as evident when the individuals are placed within sexes. The male sample mainly contains mid adults, but by contrast the female sample is not dominated by any age group.

Each of the time periods also reflects the overall pattern of dominance by mid adults. In each phase, mid adults comprise the majority (Figure 13). Examination of the young adult sample shows a higher proportion in the Early Iron Age in comparison with the mid and Late Bronze Age (Table 8). A graph showing the percentage of each age group within each phase shows that the Early Iron Age clearly is different to the other phases (Figure 13). In the Early Iron Age, young adults make up close to 40% of the sample of that phase. No sex dominates the young adult group within the Early Iron Age (Table 9). The Ban Non Wat sample is considered to be a representative sample of the population. One of the indicators of this is seen in the ratio of males to females. The sample contains a similar number of male and female individuals (Table

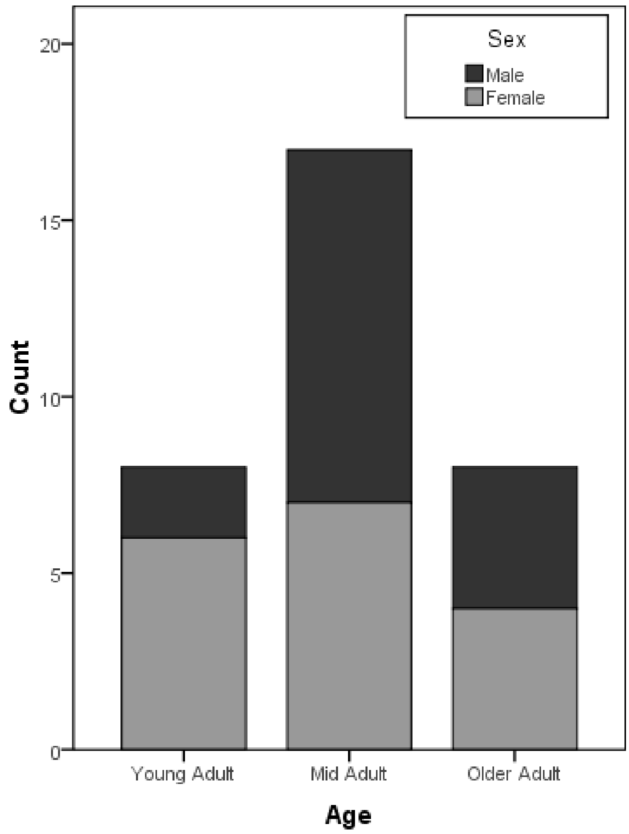

Figure 12: Age breakdown of adults in Ban Non Wat, also categorised into sexes.

7). The ratio is 1:1.1. This parity is seen as being evidence of valid representations of populations for cemetery sites (Waldron, 1994). Only five individuals could not be confidently sexed. Another test of representation is the equal spread in age range. In this sample, mid adults dominate, which suggests that population representation is not present. When divided into phases, this domination of mid adults is not pronounced. A third test of population representation is sub-adult proportions (Weiss, 1973). The proportion of sub-adults for the Ban Non Wat collection has not yet been calculated as the collection is still being analysed.

Table 7: Age determination of Ban Non Wat sample by sex.

			SEX			TOTAL
			MALE	**FEMALE**	**UNKNOWN**	
Age	Young adult	*Count*	2	6	1	9
		% within Age	22.2%	66.7%	11.1%	100.0%
		% within Sex	12.5%	35.3%		
		% of Total	5.3%	15.8%	2.6%	23.7%
	Mid adult	*Count*	10	7	4	21
		% within Age	47.6%	33.3%	19.0%	100.0%
		% within Sex	62.5%	41.2%		
		% of Total	26.3%	18.4%	10.5%	55.3%
	Older adult	*Count*	4	4	0	8
		% within Age	50.0%	50.0%		100.0%
		% within Sex	25.0%	23.5%		
		% of Total	10.5%	10.5%	0	21.1%
Total		*Count*	16	17	5	38
		% Total	42.1%	44.7%	13.2%	100.0%

Table 8: Age determination of Ban Non Wat sample by phase: count of individuals.

	PHASE			TOTAL
	MIDDLE BRONZE AGE	**LATE BRONZE AGE**	**EARLY IRON AGE**	
Young adult	2	1	6	9
Mid adult	7	6	8	21
Older adult	4	2	2	8
Total	13	9	16	38

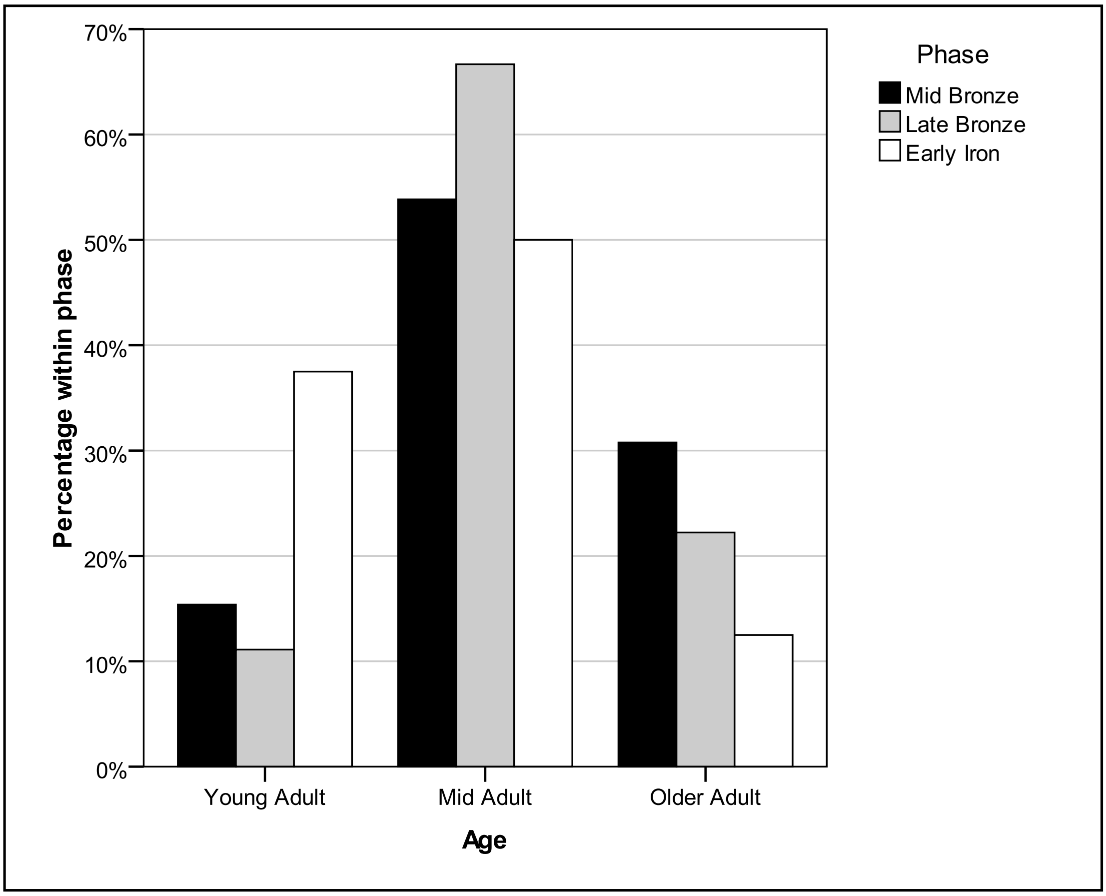

Figure 13: Age groups as a percentage of each phase at Ban Non Wat.

Table 9: Cross tabulation of sex and age groups in each phase at Ban Non Wat.

			SEX			**TOTAL**
			MALE	**FEMALE**	**UNKNOWN**	
Mid Bronze	Age	*Young adult*	0	2	0	2
		Mid adult	5	2	0	7
		Older adult	3	1	0	4
		Total	8	5	0	13
Late Bronze	Age	*Young adult*	0	1	0	1
		Mid adult	3	2	1	6
		Older adult	1	1	0	2
		Total	4	4	1	9
Early Iron	Age	*Young adult*	2	3	1	6
		Mid adult	2	3	3	8
		Older adult	0	2	0	2
		Total	4	8	4	16

4.1.4.6 Results – Age - Noen U-Loke

The results of the census assessment for Noen U-Loke are presented in this sub-chapter. The Noen U-Loke sample contains a large proportion of young adults in comparison to the other adult groups (Table 10 and Figure 14). Young adults make up almost 50% of the sample. The majority of the young adults are males, and young adults overwhelmingly dominate the male sample[14]. Females are relatively equally distributed in each age group.

The Noen U-Loke sample is dominated by young adults in the Early Iron Age, but an almost equal number of young and mid adults in the Mid Iron Age (Figure 15 and Table 11). Older adults are few in both phases. This may indicate that in the Early Iron Age young adults were dying at a proportionally higher rate than other age groups. Males dominate the young adult sample in both Iron Age phases (Table 12).

The Noen U-Loke sample is regarded as being representative of the population (Tayles et al., 2007). An indicator of representativeness has been identified in the ratio of males to females (1:0.8) for the sub-sample used in this study. Whilst the ratio in the sample is not equal, it is not significantly different and therefore representative of populations found in cemetery sites (Waldron, 1994). For the entire Noen U-Loke collection, the ratio was also calculated at 1:0.8 (Tayles et al., 2007). Whilst not considered equal in ratio, however, other measures of representation were also tested. This includes sub-adult proportions of between 30 and 70% (Weiss, 1973) and an equal spread of young, mid and older adults. Whilst the sub-adult proportion suggested population representation, the relatively high percentage of young adults suggested otherwise. Tayles et. al. (2007) argues that a large quantity of the sample could not be aged or sexed and this may have caused the disparity in sex ratio and young adult dominance. They conclude that the collection can be considered to be representative of the population.

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[14] Recently NUL61, which has been designated as a male, has been reassigned as potentially being a female based on the morphology of the sacrum and possible preauricular pitting (K. Domett, pers. comm). For the purpose of this study NUL will remain a male until the results of a reanalysis of sex determination for NUL61 and any other Noen U-Loke individual are finalised.

Table 10: Age determination of Noen U-Loke sample.

			SEX			TOTAL
			MALE	**FEMALE**	**UNKNOWN**	
Age	Young adult	*Count*	12	5	4	21
		% within Age	57.1%	23.8%	19.0%	100.0%
		% within Sex	63.2%	31.3%	50.0%	
		% of Total	27.9%	11.6%	9.3%	48.8%
	Mid adult	*Count*	4	5	4	13
		% within Age	30.8%	38.5%	30.8%	100.0%
		% within Sex	21.1%	31.3%	50.0%	
		% of Total	9.3%	11.6%	9.3%	30.2%
	Older adult	*Count*	3	6	0	9
		% within Age	33.3%	66.7%	.0%	100.0%
		% within Sex	15.8%	37.5%	.0%	
		% of Total	7.0%	14.0%	.0%	20.9%
Total		*Count*	19	16	8	43
		% of Total	44.2%	37.2%	18.6%	100.0%

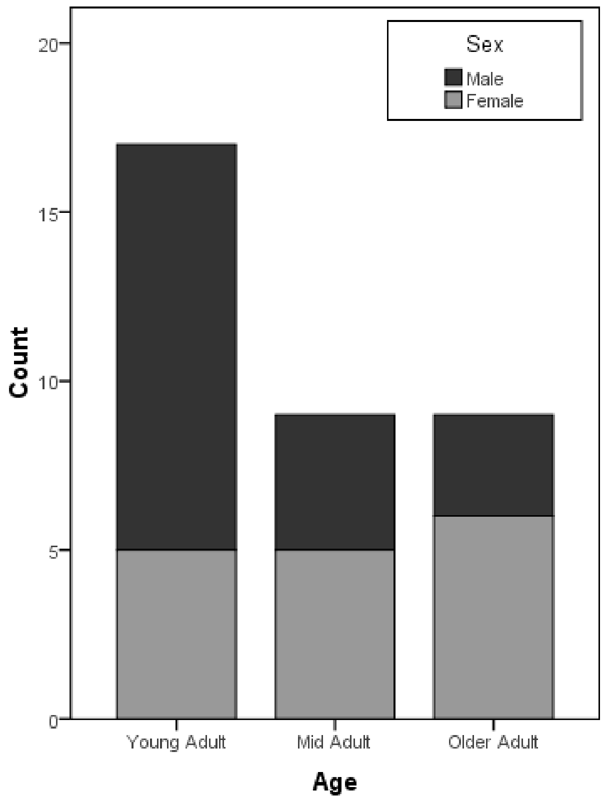

Figure 14: Age breakdown of adults in Noen U-Loke, also categorised into sexes.

Table 11: Age determination of Noen U-Loke sample by phase.

	PHASE		TOTAL
	EARLY IRON AGE	MID IRON AGE	
Young adult	9	12	21
Mid adult	3	10	13
Older adult	4	5	9
Total	16	27	43

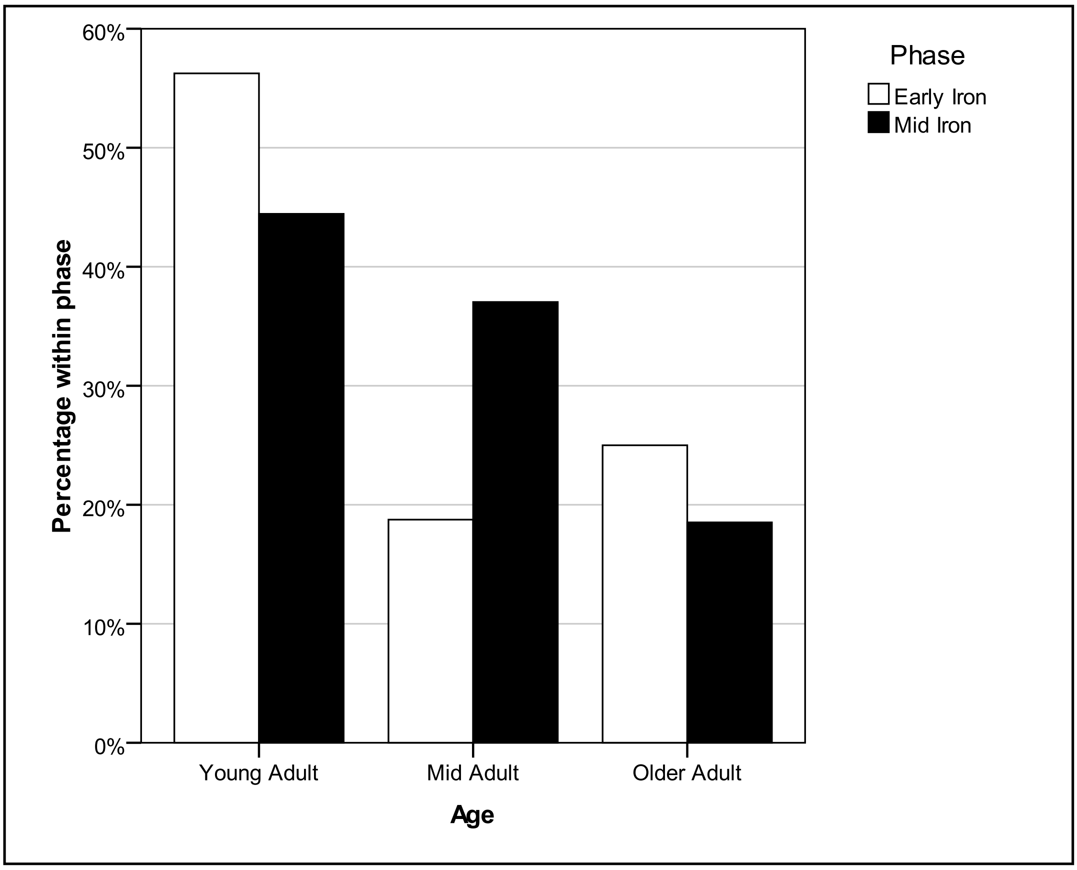

Figure 15: Age of Noen U-Loke sample as a percentage of each phase.

Table 12: Cross tabulation of sex and age groups in each phase at Noen U-Loke.

			SEX			TOTAL
			MALE	FEMALE	UNKNOWN	
Early Iron	Age	*Young adult*	6	3	0	9
		Mid adult	1	2	0	3
		Older adult	1	3	0	4
	Total		8	8	0	16
Mid Iron	Age	*Young adult*	6	2	4	12
		Mid adult	3	3	4	10
		Older adult	2	3	0	5
	Total		11	8	8	27

4.1.4.7 Ban Non Wat and Noen U-Loke - Consideration of Age and Sex

Using the census sample data, a comparison of age patterns between Noen U-Loke and Ban Non Wat can be made. The sub-sample sizes, especially for Ban Non Wat, are small and there is an understanding of the limitations regarding any detailed census assessment. The sex ratios within each sub-sample are fairly similar with fairly equal representation of males and females. The frequency of adult age groups within each site can be seen in Table 13. Young adults dominate the Noen U-Loke sample, whilst Ban Non Wat has a large number of mid adults. Over 70% of all of the young adults died at Noen U-Loke, and over 60% of all of the mid adults at Ban Non Wat. A Chi-square test for independence or relatedness shows that this result is significant: χ^2 (2, N=81) = 6.457, p<.05.

At Ban Non Wat mid adults dominate every phase, but there is a difference between the Bronze and Iron Ages. The Bronze Age has higher numbers of older adults, but this is reversed in the Iron Age where there are more young than older adults (Figure 13). This potentially shows change in mortality patterns between the Bronze and Iron Age. Further examination of the entire Ban Non Wat skeletal collection would be useful to test whether or not this is a true reflection of the mortality patterns seen here. A Chi-square test for relatedness or independence was conducted to test the hypothesis that a particular age and time period dominated the sample. A cross tabulation of the age frequencies within each phase can be found in Table 14. This hypothesis was rejected and there is no particular time period that is dominated by any age group: χ^2 (6, N=81) = 7.610, p>.05.

Table 13: Cross-tabulation of sites and age groups at Ban Non Wat and Noen U-Loke.

			SITE		**TOTAL**
			BAN NON WAT	**NOEN U-LOKE**	
Age	Young adult	*Count*	9	21	30
		% within Age	30.0%	70.0%	
		% within Site	23.7%	48.8%	
		% of Total	11.1%	25.9%	37.0%
	Mid adult	*Count*	21	13	34
		% within Age	61.8%	38.2%	
		% within Site	55.3%	30.2%	
		% of Total	25.9%	16.0%	42.0%
	Older adult	*Count*	8	9	17
		% within Age	47.1%	52.9%	
		% within Site	21.1%	20.9%	
		% of Total	9.9%	11.1%	21.0%

Table 14: Cross-tabulation of age and time period at Ban Non Wat and Noen U-Loke.

			PHASE				TOTAL
			MID BRONZE	LATE BRONZE	EARLY IRON	MID IRON	
Age	Young adult	Count	2	1	15	12	30
		% within Age	6.7%	3.3%	50.0%	40.0%	
		% within Phase	15.4%	11.1%	46.9%	44.4%	
		% of Total	2.5%	1.2%	18.5%	14.8%	37.0%
	Mid adult	Count	7	6	11	10	34
		% within Age	20.6%	17.6%	32.4%	29.4%	
		% within Phase	53.8%	66.7%	34.4%	37.0%	
		% of Total	8.6%	7.4%	13.6%	12.3%	42.0%
	Older adult	Count	4	2	6	5	17
		% within Age	23.5%	11.8%	35.3%	29.4%	
		% within Phase	30.8%	22.2%	18.8%	18.5%	
		% of Total	4.9%	2.5%	7.4%	6.2%	21.0%
Total		Count	13	9	32	27	81
		% of Total	16.0%	11.1%	39.5%	33.3%	100.0%

4.1.4.8 SEAHI Methodology – Age At Death

The methods for age at death estimation in the Noen U-Loke dataset was based on recording the state/stage of epiphyseal long bone fusion and Brooks and Suchey pubic symphysis morphology found in Buikstra and Ubelaker (1994: 23-4, 43) and rates of tooth wear as described in Molnar (1971) (Tayles et al., 2007). Preliminary age range estimation was conducted on the Ban Non Wat sample, using the same Buikstra and Ubelaker (1994) standards, but tooth wear was not recorded specifically, or estimated by seriating using grades, but was taken into account by relative observation (Table A 1 [p. 358]).

4.1.5 Dental Health

Permanent teeth are formed from infancy to early adulthood (Hillson, 2000). Effects of diet and hygiene as well as other conditions can be found on teeth, as unlike bone, teeth cannot heal any injuries or insults. The permanent teeth and their surrounding bone offer an indication of events in an individual's life.

By studying the dentition of an individual, or sample population, the standard of living or lifestyle of that individual can be better understood (Mayhall, 2000). Examining populations over time can identify trends in diet and dental hygiene and their effect on health. There are a number of pathological variables within the dentition; these include calculus and periodontal disease. The majority of bioarchaeological studies dealing with dentition have focused on diet, as food has a large impact on teeth, especially if dental hygiene is poor. Hillson (2000) has shown the interrelation of the different dental conditions that highlights the importance of considering the various dental pathologies as a continuum, not in isolation to each other.

Researchers choose to focus either on one aspect or many aspects of dental health in order to understand the health and diet of a population. For example, six dental indicators were used to look at the health of Napoleon's army of 1812 excavated from a mass grave (Palubeckaite et al., 2006), four were used on prehistoric American Indians (Sciulli, 1997) and within a Roman population in Italy (Bonfiglioli et al., 2003), whilst only two dental indicators were used in the study of the Maya at Peten (Cucina and Tiesler, 2003). It is debatable how many aspects of dental conditions are required to provide an adequate indication of dental health. The dental pathologies discussed and identified in the current study include periapical cavities, infrabony pockets and caries. The bone surrounding the teeth can contain indications of dental pathologies. In addition, tooth wear and ante-mortem tooth loss can also provide information about dental health and are also included. These indicators provide a representative amount of information regarding dental health and diet.

4.1.5.1 Alveolar Bone Health

Dental hygiene in prehistoric populations and individuals can be identified by the presence of periodontal disease. Periodontal disease is an infection caused by plaque build-up, which in turn has an effect on the bone in the mandible and maxilla (Hillson, 2000). The inflammation and recovery pattern causes alveolar bone loss and subsequent remodelling, often causing ante-mortem tooth loss. Once the tooth is lost, the bone in the socket remodels again. The area becomes smooth and can appear as if no socket was ever there. The molars are the most commonly affected teeth from periodontal disease.

Generally, periodontal infection advances apically and initiates horizontal loss of alveolar bone. Where the infection spreads along adjacent to the root, it impacts on the crest of the alveolar bone and results in pockets of bone loss and infrabony pockets are formed (Papapanou and Tonetti, 2000, Sivapathasundharam, 2009). There are two types of infrabony pockets identified by Papaoanou and Tonetti (2000):

1. Intrabony defects
2. Craters

Infrabony defects (see Figure 16) can be broad or narrow and are commonly identified as having one of the following attributes (based on Sivapathasundharam, 2009):

1. Three Wall. The defect is located in the interdental areas and there are three walls of the alveolar process that are intact – the proximal, lingual and buccal. This is the most common infrabony defect.
2. Two Walls. The defect is located in the interdental area, the buccal and lingual alveolar walls are intact.
3. One Wall. This is less common and located in the interdental area where only one wall

is still evident.

Craters are cup or bowl shaped defects that are also interdental and bone loss is nearly equal on neighbouring teeth.

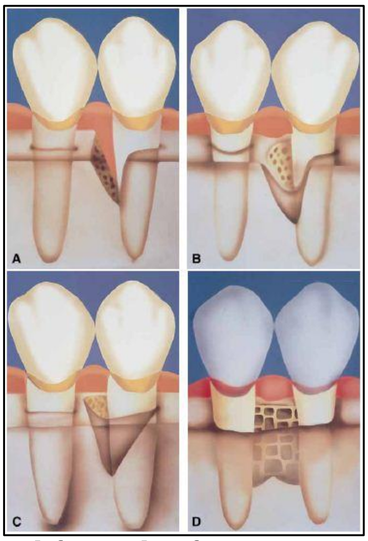

Figure 16: Stages of infrabony defects, taken from Papapanou and Tonetti (2000 :Figure 2)[15].

Results - Periodontal Disease in Ban Non Wat and Noen U-Loke

In the Ban Non Wat sample, each tooth position was examined for periodontal disease and a simple presence/absence of either generic periodontal disease or infrabony pockets was recorded. Twelve individuals of the Ban Non Wat sample had evidence of periodontal disease, either in the form of infrabony pockets or horizontal alveolar bone loss (Table A 2 [p. 375]). The ages are almost equally spread between mid and older adults, although there is one young adult with periodontal disease. There is no differentiation between the sexes. The Mid Bronze and Early Iron ages have the majority of the afflicted individuals with over a quarter of the sample from within these periods having periodontal disease (Table A 3 [p. 377]). Close to half the Mid Bronze Age sample suffered from periodontal disease. There is one individual in particular that stands out. Burial BNW319 is an older female from the Early Iron Age and a large proportion of the alveolar bone around her teeth has been affected by periodontal disease. Her dental hygiene appears to have been considerably poorer than other older adults (Table A 2 [p. 375]).

In the Noen U-Loke samples, the preservation of the bone surrounding the dentition was poor.

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[15] A – One Wall Infrabony Pocket
B- Two Wall Infrabony Pocket
C- Three Wall Infrabony Pocket
D- Crater

Tayles et al. (2007) had difficulty identifying resorption of the alveolar crest. However, three individuals were identified as having periodontal disease. They were three females of mid to old age and the periodontal resorption was identified in the mandible in all three individuals.

Periapical cavities

When the pulp of the tooth is exposed, by caries or fracture, micro-organisms can enter the pulp, causing an immune response and inflammation (Hillson, 2000). In most occasions, the bacteria travels down the root canal to the apical foramen, which causes inflammation in the tissues around the root apex. There are many scenarios, including bone loss, formation of granulation tissue and small cavities created and eventual tooth loss. These cavities are termed periapical cavities. Alveolar bone cavities have been erroneously identified previously as the result of abscesses (Dias and Tayles, 1997). Dias and Tayles (1997) point out that these cavities are more likely to be from periapical granulomas and apical periodontal cysts.

Periapical cavities in a population can be indicators of other health and social issues. Domett (2001: 126) states that “Populations with high rates of caries and/or advanced attrition may be more vulnerable to developing periapical infections, particularly if the immune response is lowered by, for example, an inadequate diet.” The presence of numerous periapical cavities in an individual may suggest that the person was healthy enough to withstand these infections, but these lesions may also be contributors to death (Dias and Tayles, 1997). Severe acute response to a periapical infection may result in osteomyelitis, which is characterized by a large quantity of bone loss (Hillson, 2000). When immunity is low, or the infection highly virulent, osteomyelitis can cause a systemic response, septicaemia and if untreated, death.

Results - Periapical cavities in Ban Non Wat and Noen U-Loke

At Ban Non Wat, there are six individuals (16% of population sample) that show evidence of periapical cavities (Figure 17 and Table A 4 [p. 378]). The individuals are either young or mid aged adults. None were older adults. All phases were represented. Of the number of tooth positions that have periapical cavities, only 0.85% of tooth positions were affected. Approximately 2% of tooth positions of young adults were affected, as opposed to 0.54% of mid adults.

At Noen U-Loke, a large number of individuals had periapical cavities (37.8% [14 individuals affected from 37 observed]). The proportion of tooth positions with periapical cavities is 6% (Tayles et al., 2007). Females make up the larger proportion of those affected. Tayles et al. (2007) state that the periapical cavities are more likely to be the result of caries or pulp exposure from attrition and not periodontal infection.

Figure 17: Periapical cavity in a young female adult BNW549.

4.1.5.2 Caries and Ante-mortem Tooth Loss

Dental caries are the result of the fermentation of carbohydrates and starches by plaque bacteria (Hillson, 2000). Whilst starchy foods are not thought to have a high cariogenic potential, in combination with sugars, such as sucrose, they increase the cariogenicity of the diet. This may be the result of starches that "prolong the retention time of the product in the mouth" (Lingstrom, 1993: 99). Carbohydrates, such as sucrose, glucose and fructose, are "readily metabolized by many bacteria involved in dental biofilm formation, generating acid by-products that can lead to demineralization of the tooth structure" (Fejerskov and Kidd, 2008: 338). The acid from the bacteria causes the decay, initially softening the enamel, and forming a cavity (Mays, 1998). When the decay encounters the dentine and cementum, it causes demineralisation, where the pulp may be exposed to infection. Unlike gingival infection, caries do not cause bone resorption; therefore, the root of the tooth is able to stay firmly in place. If infection spreads down into the root canal, it could lead to a periapical cavity.

The growth of caries is not constant, being active and inactive over long periods of time (Hillson, 2000). Molars are more susceptible than incisors or canine teeth, as are upper teeth. There are different types of caries. They can be classified based on their location, for example, coronal or root surface. The caries that are seen in archaeological contexts are generally from the late stages of the condition, as early stages can only be seen microscopically. Whilst caries themselves do not cause ante-mortem tooth loss, the pain and damage associated with caries can lead to the deliberate removal of the tooth in order to ease suffering and lead to an infection via the pulp canal.

Caries have not been recorded consistently in archaeological contexts (Hillson, 2001). In the past, methodologies included calculations of the number of carious teeth as a percentage of surviving teeth or the number of individuals affected by caries as a percentage of a sample (Mays, 1998). Hillson (2001) believes that these methods underestimate the prevalence of caries, as the majority of individuals would have had teeth with caries extracted prior to their deaths. Another important fact that needs to be taken into account is that the older the age of a population, the longer the time that was available for caries to be formed (Mays, 1998). Hillson (2001) has looked at a number of methods, none without some flaw, including the method commonly used today, found in Buikstra and Ubelaker (1994), which calculates three types of caries: occlusal; interstitial and buccal. In investigating caries recording, Hillson (2001) looked at the ramifications of post-mortem tooth loss, recording carious data from broken teeth, impaction and unerupted teeth. Hillson (2001) believes that by recording information of each tooth separately then the impact on missing or inadequate data will be lessened.

Investigating caries in human skeletal remains is very important, as the diet of the population can be better understood. The transition from a hunter-gatherer lifestyle to that of an agricultural society is often cited as the period where the diet adversely impacted the dental health of populations (Larsen, 1983, Walker and Hewlett, 1990, Hillson, 2000). Hunter-gatherer communities generally ate unrefined foods that are starchy and grittier, whilst individuals in agricultural societies had more cariogenic carbohydrates, for example in the Americas maize was a common crop. This pattern is not repeated in Southeast Asian sites (Tayles et al., 2000, Tayles et al., 2009, Newton et al., 2013) or even in European sites (Molnar and Molnar, 1985, Lubell et al., 1994). Tayles et al. (2000) looked at three sites in Thailand, including a hunter-gatherer site, a Bronze Age site and an Iron Age site. All of these sites were occupied after rice became cultivated in the region. They found, in the limited samples studied, that caries decreased in frequency with time, rather than increased. There is also some recent evidence to suggest an increase in caries in the late Iron Age in Cambodia (Newton et al., 2013). Rice is the mainstay carbohydrate in the diet of the inhabitants. The cariogenicity of a carbohydrate is determined by its molecular weight, with those of a low weight considered the most cariogenic (Mays, 1998). Carbohydrates that have a low molecular weight are able to permeate into plaque and are quickly metabolised by bacteria (Garg and Garg, 2010). Rice appears to be less cariogenic than other carbohydrate foods, but cooked starches can also be broken down to a low molecular weight by enzymes in the mouth (Fejerskov and Kidd, 2008). Tayles et al. (2000) also identifies other variables that impact on the formation of caries, such as age of the individual, the type of caries causing bacteria and morphology of teeth.

Results - Caries in Ban Non Wat and Noen U-Loke

The prevalence of caries by individuals and by number of teeth can be seen in Table A 5 [p. 379]. There are individuals in both Noen U-Loke and Ban Non Wat samples that are affected. Young adults are also affected, although the sample of young adult males in Ban Non Wat is small. There appears to be a larger proportion of mid to older adults with caries in Ban Non Wat than in Noen U-Loke, but the breakdown between mid and older adults in Ban Non Wat shows that a large proportion of older adults have caries compared to mid aged adults (Figure 18). This breakdown was not reported by Tayles et al.(2007). In Noen U-Loke, the proportion of young adults with caries is slightly higher than mid to older adults. A larger number of teeth in younger adults (5.8%) at Ban Non Wat have carious lesions than mid aged adults (3.5%) (Figure 18). Older adults have a longer period to develop caries and the percentage of teeth is understandably higher than young and mid aged adults (7.1%).

There is a possibility that the young adults that died with carious lesions had infant or childhood caries. Childhood caries may have been caused by prolonged breast feeding or due to medical conditions (Fejerskov and Kidd, 2008). The high prevalence of caries in young adults at both sites, but especially Ban Non Wat, is suggestive of poor health possibly unrelated to carious lesions. The death of these young adults would not have been caused by caries, but by some other affliction or accident. The high incidence does suggest that a high cariogenic diet and poor oral hygiene was evident in these individuals from a young age. The caries evident are representative of later stages in carious erosion and prolonged poor mouth hygiene would have been required to cause carious lesions in young adults. There is no statistical significance in the prevalence of caries according to age range (χ^2 [2,N=38] = 3.205, $p>0.05$), but this also indicates how unexpected the finding is. Many other studies show a statistical difference between young and older adults.

At Ban Non Wat, the number of individuals affected by caries is lowest in the Mid Bronze Age (38%), although comparatively, a slightly greater number of teeth are affected at this time (Table 15). So, although a smaller number of people are affected, they have more carious teeth than later periods. The Early Iron Age period sees males less affected by carious lesions than females. There is no statistical significance between phase and the presence of caries by individual (χ^2 [2,N=38] = 0.700, $p>0.05$) or overall trend of caries according to sex by individuals (χ^2 [1,N=33] 0.750, $p>0.05$). When looking at numbers of affected teeth, there is no significance according to sex (χ^2 [5,N=33] = 4.367, $p>0.05$), phase (χ^2 [10,N=38] = 9.834, $p>0.05$) or age (χ^2 [10,N=38] = 12.322, $p>0.05$). Caries prevalence is highest in the Early Iron Age in Noen U-Loke (Table 15). In the Noen U-Loke sample there is a statistically significant relationship between phase and the number of individuals with caries (t[41]=2.063, $p<0.05$) and between phase and number of teeth affected by caries (t[41]=2.197, $p<0.05$). Males and females in the Early Iron Age appear to be particularly affected, and there is no statistically significant difference between the sexes in this phase (number of affected teeth t[14]=0.509, $p>0.05$; number of individuals affected t[14]=-0.135, $p>0.5$). This result is replicated in the Mid Iron Age (number of affected teeth t[17]=-1.311, $p>0.05$; number of individuals affected t[17]=0.986, $p>0.5$). There is however a statistically significant difference between males in the Early Iron Age and Mid Iron Age in Noen U-Loke (number of affected teeth t[17]=2.207, p<0.05; number of individuals affected t[17]=2.207, p<0.5). Comparatively, there is no statistically significant difference between the females of the Early and Mid Iron Age in Noen U-Loke (number of affected teeth t[14]=0.649, p>0.05; number of individuals affected t[14]=0.475, p>0.5).

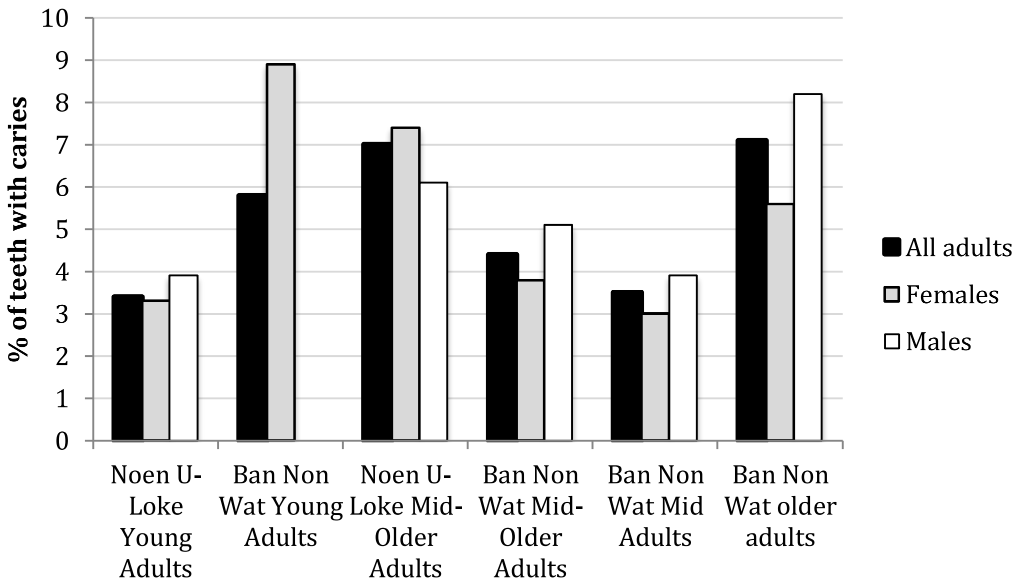

Figure 18: Percentage of teeth with caries at Noen U-Loke and Ban Non Wat, by age group.

Table 15: Prevalence of caries by period at Ban Non Wat and Noen U-Loke (sample from this study only).

Period	ALL ADULTS AFFECTED /NO OF INDIV. (%)	FEMALE AFFECTED/ NO OF INDIV. (%)	MALE AFFECTED/ NO OF INDIV. (%)	ALL ADULTS AFFECTED/ NO OF TEETH (%)	FEMALES AFFECTED/ NO OF TEETH (%)	MALES AFFECTED/ NO OF TEETH (%)
BNW Mid Bronze	5/13 (38%)	2/5 (40)	3/8 (38)	16/287 (6)	7/100 (7)	9/187 (5)
BNW Late Bronze	5/9 (55%)	2/4 (50)	3/4 (75)	12/217 (6)	4/84 (5)	8/114 (7)
BNW Early Iron	8/16 (50%)	6/8 (75)	1/4 (25)	13/369 (4)	9/178 (5)	1/89 (1%)
NUL Early Iron	11/16 (69%)	5/8 (63%)	6/8 (75%)	25/349 (7%)	13/163 (8%)	12/186 (6%)
NUL Mid Iron	10/27 (37%)	4/8 (50%)	3/11 (27%)	17/524 (3%)	4/220 (1.8%)	8/178 (4%)

A complicating factor in the analysis of caries at Ban Non Wat and Noen U-Loke is the effect of attrition on the prevalence and severity of caries (Larsen, 1997). Attrition may have a negative or positive impact on the presence of caries. Caries are commonly formed in the fissures of the occlusal surface of the molars, for example; this is also the location where attrition can be focused. Evidence of carious lesions may have been worn away. The rate at which attrition is occurring would have an impact on whether or not carious lesions are affected. In addition, attrition would have a smaller impact on cervical caries. Maat and Van der Velde (1987) have identified a negative relationship between caries and attrition, the more severe the attrition, the lower prevalence of caries and vice versa. The caries identified in their study were formed in the fissures of the tooth and not in the dentine following attrition. Conversely, there are some studies that have found a positive relationship. Meiklejohn et al. (1992) have identified a relationship of higher rates of attrition with a high caries rate. Due to the conflicting results, Meiklejohn et al. (1992) suggest that there is no dependant relationship between attrition and caries, and that diet is the correlating factor. A simple comparison of attrition and caries in Ban Non Wat shows less caries in the mid adult group than younger adults (Table 16). Almost an equal percentage of young adults have caries and tooth wear, but the amount of caries reduces in comparison to attrition in mid aged adults. Attrition appears to be masking evidence of some caries in the later stages.

Table 16: Simple comparison of age groups in Ban Non Wat by percentage of individuals with caries and attrition.

AGE	ATTRITION %	CARIES %
Young adult	45	44
Mid adult	58	38
Older adult	100	75

Ante-mortem tooth loss (AMTL)

Tooth loss is generally related to three causes according to Hillson (2000). These are:

1. Deliberate extraction or ablation;
2. Periapical inflammation causing bone loss in association with periodontal disease and the elimination of the alveolar crest; and
3. Periapical inflammation caused by micro-organisms entering the pulp from caries and fractures.

Lukacs (2007) also lists diet and nutritional deficiencies as pre-cursor causes of AMTL.

Ante-mortem tooth loss can be easily identified, but it can be difficult to identify if the loss was ablation or pathological. Partial anodontia, or congenitally missing teeth is a common condition in modern populations. Some studies have shown that the maxillary lateral incisors and the second premolars are the most common missing congenital teeth (Meza, 2003, Rajendran, 2009). There are also correlations between missing deciduous teeth and permanent teeth (Rajendran, 2009).

If there is space with room for a tooth, no alveolus, as well as facet wear on adjacent teeth, it is most likely that a tooth was lost well after eruption (Nelsen et al., 2001). Interesting theories can be drawn from the study of tooth loss in populations. For example, the high incidence of missing lateral incisors in the Noen U-Loke population have been identified as being potential indicators of an isolated community with only some cases relating to sex determined ablations (Nelsen et al., 2001, Domett et al., 2013).

AMTL in Ban Non Wat and Noen U-Loke samples

The method to identify AMTL in the Ban Non Wat sample examined each individual's dentition. Tooth positions identified as 'missing with alveolar resorbed or resorbing" were considered to be AMTL.

In the Noen U-Loke sample, AMTL was identified "where there was clear evidence of the tooth having been present, in the form of a space between surviving teeth and interproximal wear facets on surviving teeth. The differentiation of teeth 'missing' ante-mortem due to either ablation or agenesis from those lost ante-mortem from dental disease was based on the pattern of tooth loss." (Tayles et al., 2007:277).

Over 50% of the Ban Non Wat sample had AMTL. There does not appear to be any difference between males and females, with a similar proportion with AMTL in the population (Figure 19). Figure 20 shows the location of the teeth lost. The higher numbers of missing third molars may be due to non-eruption and may be an overestimation. The maxilla has a larger proportion of missing teeth than the mandible. The right lateral incisor and canine on the maxilla is notable for the large proportion of teeth missing in the anterior portion of the dentition. All of the individuals with lateral incisor AMTL are mid to older adults and the majority are males. All of the missing canines belong to mid to older females and the missing central incisors predominantly can be found in mid to older aged males. At Noen U-Loke, Nelsen et al.(2001) identified a distinct pattern of missing lateral incisors relating to potentially genetic hypodontia (Table A 6 [p. 380]). A large proportion of a Noen U-Loke sub-sample (79%) had missing lateral incisors. The sub-sample comprised 38 adults who could be assessed for missing lateral incisors. This is, proportionally, considerably more than found at Ban Non Wat (13%). The majority of individuals from Ban Non Wat with missing lateral incisors belong to the Iron Age period (three of five individuals in the sample). If the large portion of missing lateral incisors is not related to pathological conditions, they should not be included in the analysis of AMTL. It is assumed that not all of the data collected as AMTL for Noen U-Loke and Ban Non Wat is related to ablation.

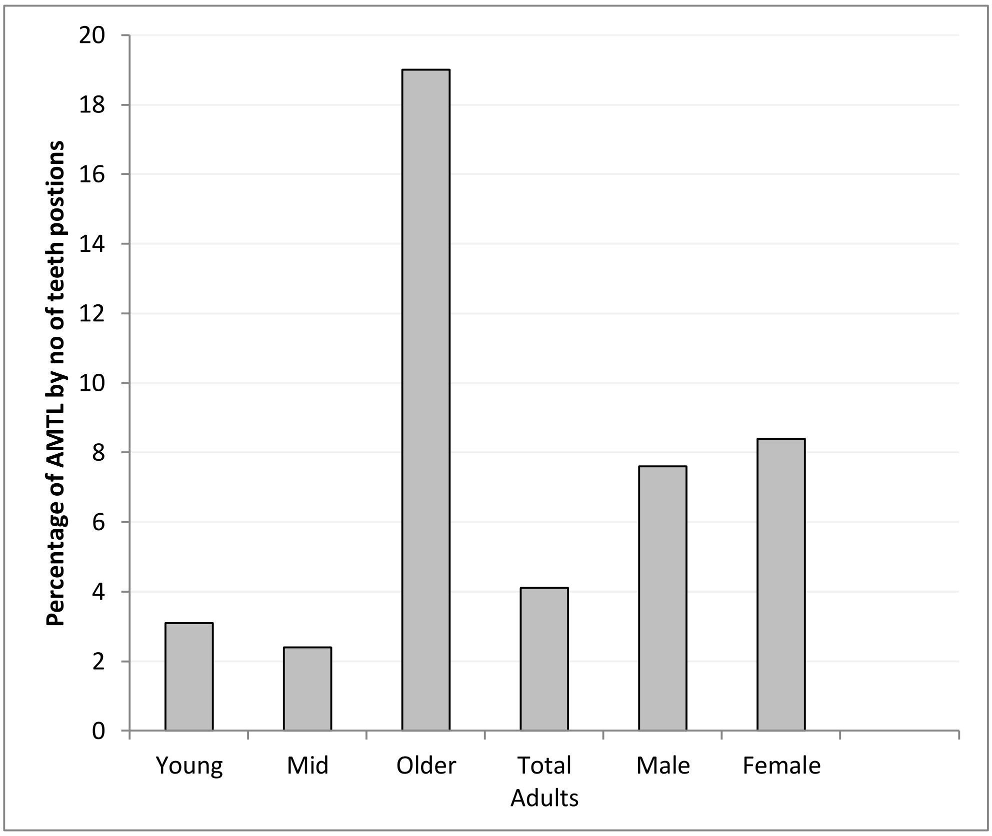

Figure 19: Percentage of AMTL by number of total tooth positions, by age group and sex at Ban Non Wat.

Noen U-Loke and Ban Non Wat have some similarities and differences (Table A 7 [p. 381]). Overall, it appears that more females have AMTL than males at Noen U-Loke whereas at Ban Non Wat the proportions are even. A higher proportion of young adults have some degree of AMTL at Ban Non Wat compared to Noen U-Loke. More older women have AMTL than older men in Ban Non Wat. A calculation on those mid to older adults with AMTL show that the average number of AMTL in males is 4.14 and females have lost an average of 3.88 teeth. The difference, however, is not significant (paired t-Test $t(6) = -0.086$, $p>0.05$). At Noen U-Loke, females had a higher average of 4.3 teeth missing and 2.16 teeth missing on average in males with AMTL, although this is not significant either [$t(5)= -1.690$, $p>0.05$].

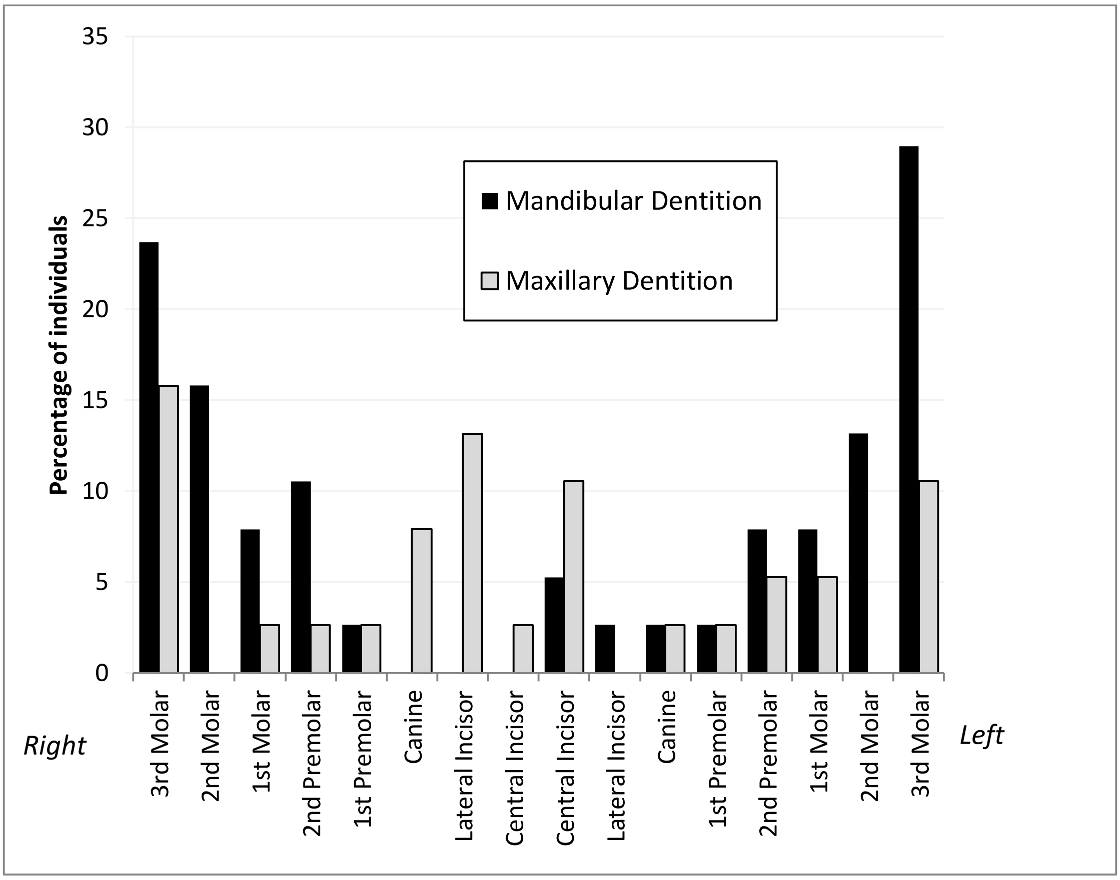

Figure 20: The percentage of individuals with AMTL within the maxillary and mandibular dentition, Ban Non Wat.

4.1.5.3 SEAHI Methodology – Dental Health

As the dental health variables were collected as standard at Noen U-Loke, no issues have arisen regarding interpretation. The dental health of the Noen U-Loke sample was recorded by Kirsten Nelsen (1999). The data was manipulated into SEAHI scores with little difficulty. The author recorded the dental health of the Ban Non Wat sample with the SEAHI methodology in mind.

A census of teeth in each individual was recorded and teeth, or tooth locations, with ante-mortem tooth loss, caries and alveolar bone cavities were identified. These dental attributes composed the scoring methodology for the dental health score (Table 19). The score for dental health is split into a 25% weighting for alveolar bone cavities and 75% for the caries and AMTL ratio. The WHHI also has this weighting. The creators of the WHHI have presently not explained why they used such a weighing split, but it is likely it is due to functional significance. Caries and AMTL have a higher weighting, as they would have more of a functional impact on an individual. The lack of an adequate number of teeth may impact individuals more than alveolar bone disease. Dental integrity can impact the nutritional intake of an individual as well as produce other effects (Appollonio et al., 1997, Kim et al., 2007). In addition, weighting the alveolar bone disease lower than AMTL/caries may assist in reducing over-recording errors. In many instances there is a relationship between AMTL and alveolar disease, as periodontal disease may result in a tooth becoming loose (Hillson, 2000). Having equal weight on caries/AMTL and alveolar bone disease may be scoring the same event twice. By placing alveolar bone disease on a lesser weighting decreases the error in dental pathology calculations.

Other differences between the dental health calculation of the SEAHI and WHHI are based on data inclusion and exclusions. The WHHI does not use individuals who have less than eight tooth positions, as the individuals are deemed "incomplete". As much of the data used in the Western Hemisphere Project is incomplete, this rule is perplexing. In this study, all teeth are used as many individuals with few surviving teeth may have caries, which is an important pathological indicator of dental health.

The WHHI only used periapical cavities in their assessment of alveolar health. Whilst a periapical cavity may have more of an impact on the quality of life of an individual, periodontal cavities and infrabony pockets also provide an insight into dental health and are included in this assessment, as they are indicative of a chronic condition. As periapical cavities are judged to be a more severe disease than periodontal disease, those with periapical cavities are scored lower than those with periodontal disease (Table 19).

Seventy-five percent of the dental score is based on caries and ante-mortem tooth loss (Table 19). This enumerates the impact of caries and AMTL against the number of tooth positions on the individual. The calculation is as follows:

1 minus the ratio of (sum of AMTL and caries): (Sum of teeth and AMTL) x 75%

As the scoring system uses 100 as the 'healthier' score and 0 as the 'unhealthy' score, a simple ratio of caries/AMTL and number of tooth positions provides an inverse score. Therefore it needs to be inverted and is subtracted from 1 to provide an appropriate score. Finally it is multiplied by 75, as it comprises 75% of the dental pathology score.

4.1.6 Trauma

Violence, medical procedures and accidents may result in trauma to the skeletal frame (Ortner, 2003, Neri and Lancelotti, 2004). Evidence of trauma may take many forms, including bone fractures, remodelling of bone, cuts or embedding of objects. Based on the presence of remodelling of the bone, it can be determined if the injury occurred ante-mortem (Lovell, 1997, Mays, 1998). A comprehensive review and classification of fractures and descriptive protocol for fracture healing was produced by Lovell (1997). Evidence of trauma is complex and can be misinterpreted, but with careful examination of the skeleton, a scenario can be devised to understand the trauma by looking at the patterning. Lovell's review and classifications have assisted in the interpretation of activities and warfare in the Bronze Age of Thailand (K.M.

Domett and N. Tayles, 2006) and Iron Age of Cambodia (Domett et al., 2011).

4.1.6.1 Trauma identified in Ban Non Wat and Noen U-Loke

Trauma was identified by examining bones for bony anomalies at Ban Non Wat (Table A 8 [p. 382]). In general, many of the lesions found on the skeleton could be attributed to either a soft tissue infection or trauma and differentiation between the two aetiologies could not be made due to the non-specific characteristics of the lesions. Eight individuals, however, did have more definite indications of trauma (Table 17). BNW 449 also has some evidence of trauma to the skull, but it is not certain that this was ante-mortem or peri-mortem.

Table 17: Indications of trauma in Ban Non Wat sample.

BURIAL	TRAUMA
123 Mid adult-Male	Fractured fibula
155 Mid adult-Male	Possible spiral fracture - left clavicle
185 Mid adult-Male	Schmorl's Nodes
229 Mid adult-Unknown Sex	Rib injury
431 Older adult-Male	Fracture right ulna
535 Mid adult-Female	Possible fracture - left ulna, styloid process
539 Mid adult-Male	Trauma to left clavicle
554 Mid adult-Female	Fractured right ulna

The samples at Noen U-Loke were in poor condition, however three skeletons exhibited indicators of trauma (Table 18). The fractured vertebrae are considered to be the most reliable representation of trauma of the three individuals.

Table 18: Indications of trauma from the Noen U-Loke sample.

BURIAL	TRAUMA
NUL 78 Mid age adult Sex unknown	Left tibia. Probably a bony response due to trauma.
NUL 87 Adult Sex unknown	Phalanx has trauma indicator.
NUL 108 Old adult Female	Traumatic fracture of vertebra.

4.1.6.2 SEAHI Methodology - Trauma

Trauma is determined by healed fractures in five areas (Table 19). Each location is allocated a score out of 20, based on the pathological severity to the bone. Further explanation of severity is:

- Moderate is when there is some minor deformity to the bone and there is evidence of healing.
- Severe is when there is healed non-union, angulations or large scale bone damage. This also includes vertebral collapse; and pseudoarthrosis – bone ends are only joined by fibrous tissue and a fibrous pseudojoint is made at the break.

The restrictions to functional physical movement are not taken into account as this is generally unknown. Perimortem trauma is not included in the analysis, as this type of trauma has no bearing on the life of the individual, only on the death; and, as such, should not impact on the health index. This scoring system departs from that of the WHHI markedly. For example, the WHHI system takes into account degrees of loss of locomotion and places larger emphasis on the tibia.

All pathological bony lesions in the dataset from Noen U-Loke were recorded by a variety of researchers including Nancy Tayles and Kathryn Domett. Descriptions of these anomalies and interpretations were also documented. Examination of the Noen U-Loke database was required to search for individuals with indicators of trauma. The SEAHI can be used retrospectively, whereas it appears that the WHHI cannot in this attribute, mainly due to its reliance on interpretation of locomotion. For the Ban Non Wat data, a specific database was set up for the recording of trauma indicators. This permitted an easier method to score this attribute.

4.1.7 Growth

The study of growth in past populations has been a prominent bioanthropological area of enquiry, especially focussed on growth disruption and its effects on the skeleton. What is salient about the study of childhood and juvenile growth is that there is a generalised, universal pattern of growth (Bogin, 1988, Larsen, 1997). For example, the schedule of deciduous teeth replacement by permanent teeth follows a common pattern throughout the world. The general tempo of the schedule between populations does, however, differ, mostly to a relatively small degree. Growth is affected by genetic and environmental variables (Hinton, 1981, Tanner, 1989). There is variation in height between individuals, sexes and populations and each individual has a genetic potential for height, which is a heritable trait. Whilst genetic factors determine body size and shape, to a large degree, the environment can regulate body size. The environmental factors include nutrition, disease, psychological and social stress, and healthcare. Children who suffer chronic nutritional deficiencies are shorter those who do not (Bogin, 1988, Tanner, 1989, Evelith and Tanner, 1990).

In many parts of the world, past agrarian cultures consumed a low diversity diet compared to hunter-gatherer and urbanised societies. In Southeast Asia, rice has been the dominant domesticated plant crop and main source of carbohydrate for thousands of years. A limited diet may cause nutritional deficiencies. For example, a limited rice based diet that contains low amounts of protein also has the ability to inhibit the uptake of Vitamin A (Deter, 2009). Vitamin A is required for bone metabolism and it has been found that people suffering from a deficiency have difficulty fighting infections (Gropper et al., 2009).

Some growth retarding events that may affect the height of a child may be negated by “catch up growth” (Prader et al., 1963, Tanner, 1981). For example where a child’s growth is retarded by poor nutrition, an intense period of good nutrition may allow the child to reach the height they would have attained if not for the nutritional deficiency.

Many bioarchaeologists believe that environmental stress has a greater impact on male stature than female; therefore, when dimorphism between the sexes decreases in a population, it indicates greater stress, although studies have shown that there are contradictory results regarding this hypothesis (Stinson, 1985, Stini, 1985, Willis, 2003). For example, Stini (1985) describes the parental investment of females as being higher than that of males, as there is an intrinsic social requirement for females to remain viably reproductive as long as possible and to raise children to adulthood successfully. As men do not have such an intensive role in reproduction, there is less investment in the maintenance of their health and therefore they are more susceptible to stress.

Determining whether a population or an individual is undergoing stress that has caused growth disruptions is difficult. Whilst a trend towards growth disruptions may be visible, the cause may not be obvious. Although the genetic makeup of the prehistoric populations of Southeast Asia is unknown, for the purpose of this study, the populations are considered to be genetically homogenous. Where the growth pattern deviates from the population norm, it is assumed that there are environmental stresses within that population.

Impact on growth in childhood is observed in two attributes: long bone lengths and evidence of enamel hypoplasia. The use of these two attributes incorporates information about childhood health into the health index, even though sub-adults, as subjects, are not included.

4.1.7.1 Long bone lengths

Long bone lengths, rather than ‘stature’ are used in this study. Long bone measurements are not converted into heights, as the use of a formulaic method allows errors to creep into the assessment (Humphrey, 2000). The length of the long bones is used to provide a relative measure of growth. Formulae for the estimation of stature were not used, as it was considered an unnecessary step. The ultimate purpose for measuring length of long bone is not to estimate living stature, but to provide a standard biometric measurement that could be used to compare individuals and groups.

Long bone lengths – Results – Ban Non Wat and Noen U-Loke

Twelve females and fourteen males from the Ban Non Wat sample had complete or measurable long bones (Table A 10 [p. 387] and Table A 11 [p. 388]). Most of these individuals had more than two long bones that could be quantified. The sub-sample of individual bone elements is quite small and a statistical analysis is unwarranted. The long bones of eleven females and twenty-one males from the Noen U-Loke sample were measured either *in situ* or were remeasured in the laboratory (Table A 12 [p. 389] and Table A 13 [p. 390]). The official report (Tayles et al., 2007) states that only nine males and four females had measurable long bones of those remeasured post-excavation.

The long bones that survived are the more robust bones. Approximately half of the BNW male sub-sample had humeri, and there were fewer representations by fibulae and radii (Table A 10, p. 387). The standard deviations appear to be high except for clavicles, but as the measurement is in millimetres, this variance does not appear meaningful. Boxplots of each element side were produced (Figure 21). Of the male sample two males stand out. Burial BNW185 is an outlier in a number of elements suggesting that this adult, mid aged adult has noticeably longer bones than the others. His left femur is particularly longer than the other samples. Burial BNW325, a young adult, has also been identified as an outlier with relatively shorter bones than the other males. Only one bone of two recorded for Burial BNW325, the left humerus, was identified as being shorter.

The male sample from Noen U-Loke, with measurable long bones, had the largest sample. The standard deviations show the majority of male long bone lengths are close to the mean (Table A 12 [p. 389]). No individuals stand out as being taller, but one individual was identified as an outlier (Figure 22). Burial NUL61 is a young male who appears to be shorter relative to the male sample.

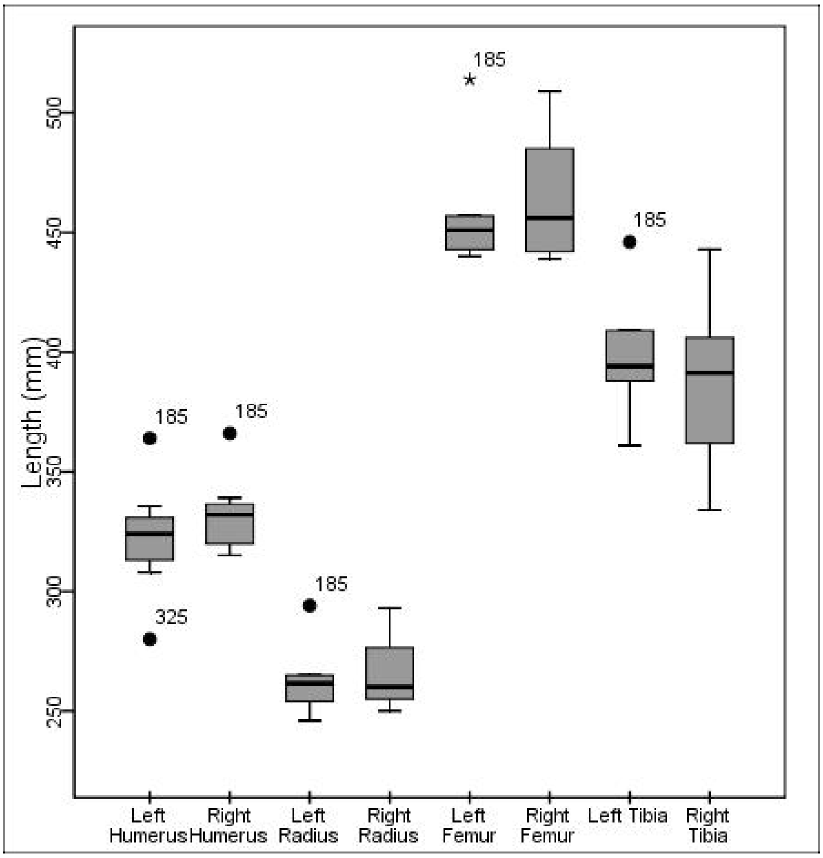

Figure 21: Boxplots of male long bone lengths (selected elements) from Ban Non Wat.

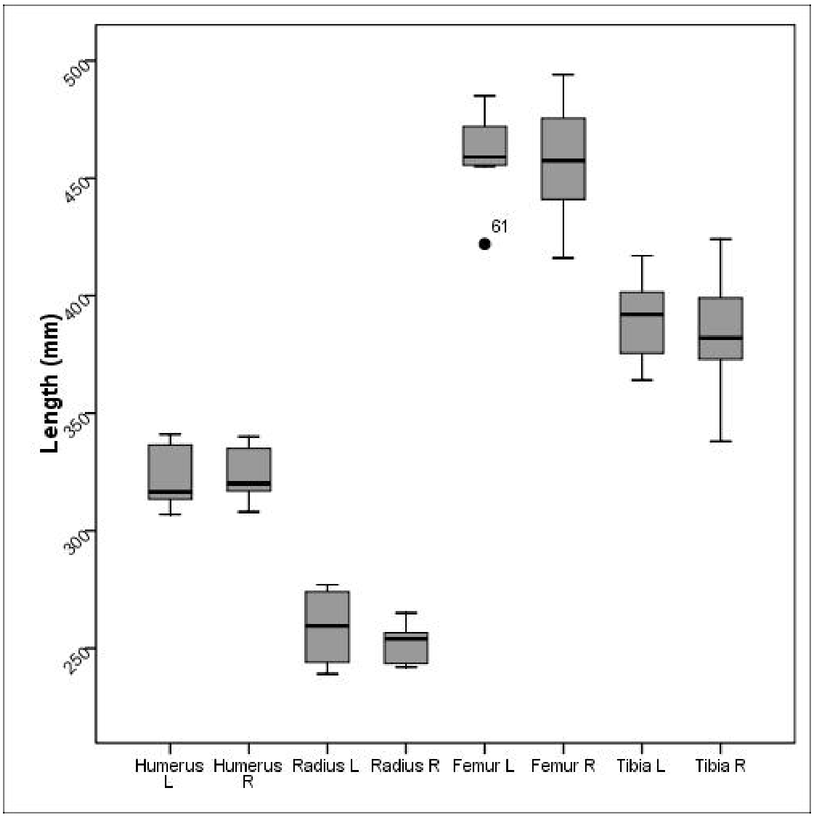

Figure 22: Boxplots of male long bone lengths (selected elements) from Noen U-Loke.

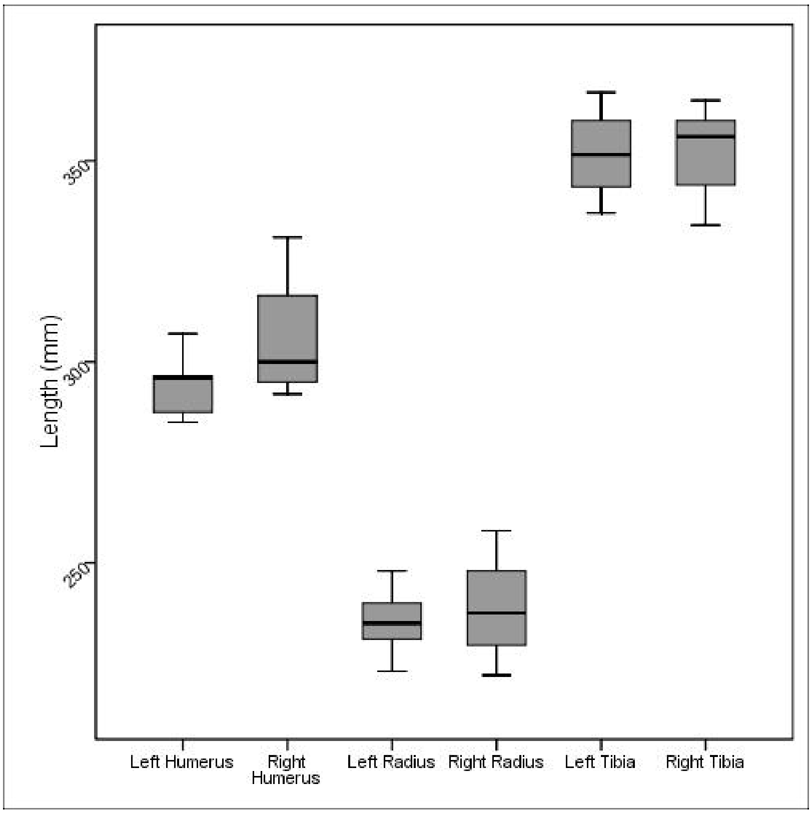

Figure 23: Boxplots of female long bone lengths (selected elements) from Ban Non Wat.

The majority of Ban Non Wat female long bones that were measurable were humeri, radii and tibiae (Table A 11 [p. 388]). The standard deviations do not show a large variation within the sample. Boxplots of elements with the largest samples show that there are no outliers (Figure 23). There are no distinctive individuals. This small sample does highlight a difference between the male and female samples. The range of long bone lengths are tighter in the female sample than the male sample. The Noen U-Loke male sample appears to show more variation in stature, suggesting differential care of children, based on sex.

The female Noen U-Loke sample is relatively poor compared to the male Noen U-Loke sample. The humerus was the only element where there were more than three examples (Table A 13 [p. 390]). The standard deviation and boxplot (Figure 24) of humerii show that the majority of females in the sample are close to the mean. No outliers were identified. The similarity of male and female variation suggests that during childhood there was a similar level of care for male and female children.

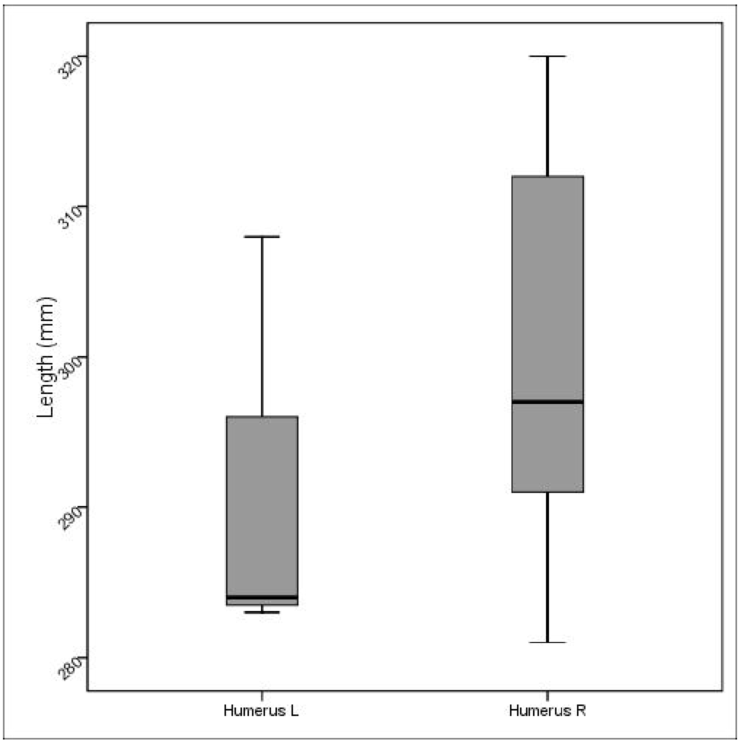

Figure 24: Boxplots of female humeral long bone lengths from Noen U-Loke.

SEAHI Methodology – Long Bone Lengths

The WHHI methodology used a ‘stature’ attribute. Long bone lengths are used in equations to estimate stature, but in both the WHHI and SEAHI a stature estimate is not used. The SEAHI long bone length attribute is the equivalent for the WHHI ‘stature’ attribute, but it is only partially based on WHHI method. The method used in WHHI uses only the femur and the femur length is then compared to modern standards (in age groups). Due to problems involved with comparing prehistoric skeletons to modern skeletons to determine whether or not an individual had poor childhood growth, this method was discounted in favour of compiling a prehistoric, regional control group. A control group was created using all of the available adult raw bone length data from prehistoric northeastern Thai sites – these comprise the Ban Chiang database, sourced from Pietrusewsky and Toomay (2002a), the Non Nok Tha database from Douglas (1996a), and the Ban Na Di and Ban Lum Khao databases (K. Domett, pers. comm.). Collating all of the long bone data, an average for each of the long bones was then calculated as well as the standard deviation (Table A 9 [p. 386]).

The long bones from Noen U-Loke and Ban Non Wat that were measured include the femur, tibia, fibula, humerus, ulna and radius as well as the clavicle (Table A 10 [p. 387], Table A 11 [p. 388], Table A 12 [p. 389] and Table A 13 [p. 390]). At Noen U-Loke, the maximum lengths of long bones were taken using sliding calipers based on standard methods in Buikstra and Ubelaker (1994) (Tayles et al., 2007). The data for Noen U-Loke was taken directly from the

Filemaker Pro database provided by Nancy Tayles. At Ban Non Wat, the same standard methods were also used, but by using an osteometric board as well as sliding calipers. In addition, where the bone had been irreparably damaged following removal from its *in situ* position, the field reading, obtained using sliding calipers, of the maximum length was taken.

Following measurement, each bone from the individual is then graded (Table 19). Where there is more than one bone, an average of the scores for each individual is taken as the grade for that individual. The SEAHI is similar to the WHHI, as the score is based on the standard deviation from the average, but those who are within one standard deviation of the average in the SEAHI score 75, rather than that of 100 for the WHHI. This is to reward those individuals that exceed the average (over one standard deviation), as there is no reason that they should be graded the same as those who meet the average. The WHHI only penalizes those who do not reach the average, whilst the SEAHI rewards and penalizes.

4.1.7.2 Enamel Hypoplasia

Enamel hypoplasia (EH) is also an indicator of childhood growth, as it marks periods of growth interruption. Interruption in the growth of enamel on the crown in permanent teeth during childhood can be the result of various childhood episodes, including a nutritionally poor diet, famine, fevers and infections (Hillson and Bond, 1997, Zhou and Corruccini, 1998, Hillson, 2000). A defect forms in the enamel, seen as furrows, steps, and pits found around the circumference of the tooth, termed linear enamel hypoplasias (LEH) (Hillson, 2000).

The molars are the most studied teeth with regard to enamel hypoplasias, due to their apparent susceptibility to developmental stress. Other researchers advocate the use of teeth less prone to stress, or all of the teeth (Wright, 1997). For example, Usher (2000 cited in Wright and Yoder, 2003) found that enamel hypoplasias found on incisors were associated with a low risk of death and those found on the first molars had an increased risk of death. Wright and Yoder (2003) advise that the age at which the insult occurred can influence the risk of death. When teeth are severely worn, signs of enamel hypoplasia may have also been worn away (Hillson 2000). Many researchers try to compensate for this by only using the canine teeth, but this can also cause difficulties. Canine teeth could be missing from a skeleton and if enamel hypoplasias have formed on other teeth the individual will be recorded as not having enamel hypoplasia. As a result, the assessment of those 'canine only' skeletal samples will not provide an accurate representation of childhood growth disruption within that sample.

Results – Enamel Hypoplasia – Ban Non Wat and Noen U-Loke

Of the 38 individuals in the Ban Non Wat sample, only one individual (Burial BNW159) did not have complete teeth. The Ban Non Wat sample contained 873 teeth, of these, 34 (4% of teeth) exhibited evidence of enamel hypoplasia, of which eight individuals were affected (21%) (Table

A 14 [p. 391] and Table A 15 [p. 392]). Enamel hypoplasias were identified as transverse lines or pitting in the dental enamel. The majority of the individuals were males or lived in the Late Bronze Age. Teeth affected ranged from incisors to molars thus the timing of growth disruption varied greatly between individuals from infancy to puberty, the time in which the particular teeth formed. All of the individuals had at least one canine with enamel hypoplasia. The hard tissues of the canines start forming at approximately 5 months and complete crown formation at approximately 7 years (Scheid and Weiss, 2011). One individual (BNW 218) had Linear Enamel hypoplasia on most of her incisors and canines. This suggests that the growth disruption occurred between 5 months and 5 years. Another individual (BNW 123) had hypoplasias in canines, premolars and a molar, implying that the insults occurred between the ages of 3 and 6. The majority of the enamel hypoplasias are on teeth that develop relatively early, in comparison to the third molar. Young children suffered insults that disrupted growth at Ban Non Wat. Twenty percent of the Ban Non Wat sample, over a long period of time, underwent stressors as children, but as the majority belong in the Late Bronze Age there is a hint that this time period was particularly problematic for children. An analysis of child mortality at Ban Non Wat in this time period would be insightful, but is beyond the scope of this study.

At Noen U-Loke enamel hypoplasias (linear enamel hypoplasia, pitting and uneven enamel) were recorded (obtained from raw data), but only linear enamel hypoplasias are reported in Tayles et al. (2007). The raw data was examined, rather than utilising the published report. As all types of enamel hypoplasias were recorded in Ban Non Wat, a comparable base was required. Table A 15 (p. 392) shows the comparison of prevalence of enamel hypoplasias within Ban Non Wat and Noen U-Loke. Noen U-Loke has high percentages of teeth and individuals with enamel hypoplasia in contrast to Ban Non Wat. Fifty three percent of adult individuals in Noen U-Loke have enamel hypoplasia, and therefore childhood growth disruptions, in comparison to 21% of adults in Ban Non Wat. In contrast to Ban Non Wat, the prevalence of enamel hypoplasia is similar in males (54.5%) and females (52.6%) in Noen U-Loke. Childhood insults appear to have been more common in the Iron Age of Noen U-Loke than that of any time period of Ban Non Wat.

SEAHI Methodology – Enamel Hypoplasia

Where there is a systemic growth disruption, enamel hypoplasias can be found on symmetrical teeth as teeth pairs erupt generally at the same time, or on a range of teeth (Suckling, 1989). It is likely that if one tooth has enamel hypoplasia, then its pair will also have enamel hypoplasia. The WHHI only records linear groove type enamel hypoplasia on the left maxillary central incisor and the left canines. The justification for this is that linear enamel hypoplasia is commonly found on incisors and canines. To better evaluate systemic growth disruptions, and maximize available data and number of individuals included, an alteration to the WHHI scoring system was implemented.

To investigate growth disruptions at Ban Non Wat, the dentition was macroscopically examined for enamel hypoplasias. Linear groove type enamel hypoplasia (LEP) and non-linear hypoplasias (pitting) were recorded and all teeth were examined for these growth defects (Table A 14 [p. 391]). The data from Noen U-Loke was obtained from raw data supplied from Nancy Tayles. To calculate a SEAHI score for enamel hypoplasia, individuals are placed within three categories based on number of teeth affected (Table 19). Individuals with more than three teeth affected get the lowest score (0).

4.1.8 Degenerative Joint Disease

There are hundreds of joint diseases or arthropathies, but only a handful can be seen in the archaeological record (Mays, 1998). Arthritic conditions are one of the major conditions found in skeletal remains (Ortner, 2003). They can restrict activity and the working capacity of an individual.

The most common disease encountered in archaeological contexts is degenerative joint disease (DJD), also identified as osteoarthritis, which is a degenerative disease of diarthrodial joint cartilage (Robbins et al., 1984, Mays, 1998). It has been defined as:

"… a group of overlapping distinct diseases which may have different etiologies, but with similar biologic, morphologic, and clinical outcomes." (Kuettner and Goldberg, 1995:vvi - x)

In DJD, the entire joint is affected, including ligaments and synovial membrane (Kuettner and Goldberg, 1995). The articular cartilage will degenerate until there is loss of the joint surface. Clinically, some of the symptoms are joint pain, inflammation and limitation of movement. Brandt (2008: 532) states that, in addition, osteoarthritis "reflects a process in the joint that is attempting to contain damage that has been caused by a local mechanical problem".

In the skeleton DJD can be identified by a number of characteristics: eburnation, bony spicules and erosion (Buikstra and Ubelaker, 1994, Ortner, 2003). Waldron (2009: 27-28) states that the bony changes on and around the articular surface include:

1. the formation of new bone around the margins of the joint, so-called marginal osteophyte;
2. the formation of new bone on the joint surface due to the vascularisation of the sub-chondral bone;
3. pitting (porosity) on the joint surface manifested as a series of holes on the joint surface, some of which may communicate with sub-chondral cysts;
4. changes in the normal contour of the joint, often widening and flattening of the contour; and

5. the production of eburnation, a highly polished area on the joint surface, usually sharply demarcated from the non-eburnated surface. The eburnated surface is sometimes scored or grooved in the direction of movement of the join, presumably due to the presence of debris, or perhaps crystals, between the two articulating surfaces.

Despite the characteristics stated above, there are some researchers who have demonstrated that there is no relationship between porosity on the intervertebral body and DJD (Rothschild, 1997), however it is still typically recorded in the assessment of DJD though not solely used as pathognomonic of DJD.

It is generally considered that the skeletal evidence of DJD seen in archaeological collections reflects more severe cases than what is clinically diagnosed today. There are a number of factors that can give rise to DJD, including age, sex, weight, level of joint activity and trauma (Waldron, 2009). Degenerative joint disease increases in frequency with age, but is dependent on sex hormones, as well as severe functional stress and strenuous activity beginning at a young age (Jurmain, 1977, Weiss, 2006).

Related to DJD is vertebral osteophytosis. This is the degeneration of the intervertebral disc and is characterised by bony spicules on the edge of the vertebral body (Mays, 1998). Scales of severity have been produced to investigate arthritis in the archaeological record. Jurmain (1990) used an ordinal scale system of morphological changes for vertebral osteophytosis and degenerative joint disease. The range went from no change to ankylosis.

4.1.8.1 Joint Disease at Ban Non Wat and Noen U-Loke

At Ban Non Wat, DJD and vertebral ostephytosis was identified using four markers: degree of lipping, degree of porosity, degree of eburnation and presence of osteophytes. All of the joint surfaces of all bones were macroscopically inspected for evidence of joint disease. Intervertebral body joint degeneration was identified by the presence of lipping, pitting, porosity of bone and osteophytes. At Ban Non Wat, DJD was evident in 26 individuals in the sample to some degree (Table A 16 [p. 393], Table A 17 [p. 403], Table A 18 [p. 411] and Table A 19 [p. 412]), although no severe forms were identified. Most had a minor or early form of DJD. Three of the individuals only had porosity indicators whilst the remainder had at least two indicators as well as intervertebral body joint degeneration. Only one individual was considered to have DJD based on a single marker. Erosive lesions on the cortical bone of the articular surface was evident in this individual, and therefore DJD was considered a possibility although it is recognised that it may have been the result of a different type of joint disease. Eburnation was not identified in any individual. Surprisingly, a large proportion of young adults had some form of DJD (78%), albeit minor. Mid adults also had a high proportion of DJD (71%), and as expected so did older adults in the Ban Non Wat sample (88%). Females are more commonly affected (94%) than males (69%). DJD is found in Mid Bronze Age (85%), Late Bronze Age (78%) and Early Iron Age (81%). Common areas of DJD are the shoulders (37%), elbows (34%), wrists (32%), hips (29%) and knees (26%). Rice farming would have been heavily reliant on the use of the upper body to dig and the higher prevalence of DJD on the upper bony joints may be indicative of a farming lifestyle. There appears to be no apparent pattern in where the younger adults contracted DJD, although most only had one joint affected, such as the hips. Two of the younger adults also had moderate DJD on the vertebrae. Over half of the sample (55%) had some form of osteophytosis on the vertebrae (Table A 17 [p. 403]). Most of these were considered to be minor in severity.

At Noen U-Loke, many of the epiphyseal ends of bones and vertebrae were in poor condition and could not be assessed. Tayles et. al. (2007) identified five individuals with features on joints and vertebrae that may be DJD (Table A 20 [p. 416]). Only one was considered to be DJD.

4.1.8.2 SEAHI Methodology – Degenerative Joint Disease

Seven joint areas of the body were examined for evidence of degenerative joint disease (Table 19). Synovial joints were examined for lipping, pitting, osteophyte formation, erosive lesions and eburnation. In addition, the bodies of the cartilaginous joints on the vertebral column were inspected for indications of osteophyte formation and pitting. The Noen U-Loke database was descriptive and had to be interpreted to be able to identify these indications of joint disease. The Ban Non Wat database was designed to identify these indicators separately and include the degree of joint disease (i.e. none, early signs of joint disease or well-progressed signs of joint disease).

Early signs of joint disease were identified as having some lipping and minor pitting, or erosive lesions (located at margins of joint). Well-progressed disease was identified in the synovial joints by the presence of eburnation, moderate to severe pitting and lipping; and for the vertebral joints, extreme lipping. Advanced erosive lesions and vertebral fusion were also considered to be signs of a well-progressed disease.

To score individuals, each of the seven joints areas are given equal weighting within the total DJD score (Table 19). The maximum score for each joint is 14.2. Early signs of joint disease are scored lower (7.2) and those areas with severe signs of joint disease score 0.

4.1.9 Childhood Cranial and Orbital Lesions

4.1.9.1 Haematopoietic childhood conditions visible in adults

There are health events that occur in childhood that are still visible on adult skeletons. Some conditions are considered to be childhood rather than adult conditions and the presence or absence of evidence of these conditions can provide an insight into the childhood of an individual and populations. Evidence of childhood specific conditions can be found in the orbital roof and on the crania in the form of cribra orbitalia and porotic hyperostosis. Previously, chronic iron deficiency anaemia was thought to produce these lesions, but numerous other causes are known to trigger the same reaction, for example gastrointestinal parasites (Holland and O'Brien, 1997).

Anaemia

Children require more iron for their daily functions including growth, than adults do (Stuart-Macadam, 1998). The effects of withholding iron in children are stronger than in adults. The causes of anaemia (iron withholding) are varied, and include diet, disease and genetic abnormality (Lewis, 2000). Some foods inhibit iron absorption including polyphenols found in some foods, including rice and soy flours, soybeans and teas (Manach et al., 2004). Weinberg (1992) describes the action of iron withholding responses that humans have to infection and chronic conditions. Foreign microbes attacking the human body require iron to function and one of the defence responses that the body has is to withhold iron, restricting access to the bacteria. There are other non-genetic conditions that have the capacity to affect the normal iron withholding response. These include excessive ingestion of iron; enhanced absorption of iron through folic acid deficiencies and anaemia; and increased release of iron in response to hepatitis.

Genetic abnormalities, in the form of alpha and beta thalassemia, can be found in Southeast Asian populations (Ortner, 2003). Haemoglobin carries iron around the body in red blood cells. Thalassemia causes poor haemoglobin synthesis, reduced red blood cell lifespan and causes an expansion within haematopoietic marrow spaces of long bones, skull and vertebrae (Waldron, 2009). Sub-adult mortality tends to be high and adult survival is low (Ortner, 2003). Signs of thalassemia in children can be found throughout the skeleton, such as the thickening of cranial vault, disorderly eruption of teeth, and reduction of cortical bone in ribs. Thalassemia has been found in prehistoric sites in Thailand, but is difficult to diagnose (Tayles, 1996). As a result, the presence of an anaemic reaction in the skeleton does not necessarily equate to a dietary lack of iron, but can be the result of other factors. The anaemic reactions that are visible in the skeleton of adults, but which mainly relate to childhood conditions are explained below.

Porotic hyperostosis

Anaemia has been linked to porotic hyperostosis lesions. These are small holes or pores that are found on the outer table of the skull, mainly the parietal and frontal bones (Aufderheide and Rodriguez-Martin, 1998, Mann and Hunt, 2005). These lesions results from thinning of the cortical bone, followed by cortical bone formation on the underlying bone, an effect of increasing red blood cell production. Whilst lesions can be seen in pitting on the outer surface of the skull vault (Mays, 1998), to be considered porotic hyperostosis, evidence of thickening of the diploë is also required. Reynolds' (1962) clinical studies identified that when the diploë is at least 2.3 times greater than the combined thickness of the inner and outer tables, then the required diploë thickening is said to have been medically achieved.

Porotic hyperostosis it generally considered to be a childhood condition, and when seen in adults, it indicates survival of the chronic condition (Stuart-Macadam, 1985). It develops as the result of many factors (Angel, 1966). A study was conducted comparing Anasazi maize farmers with the prehistoric Anasazi hunter-gatherers who lived on the Sage Plain (El-Najjar et al., 1976). It was found that over 50 percent of farmers had porotic hyperostosis, whilst the hunter-gatherers had only 15 percent. This suggests that iron deficiency induced by diet played a part in this condition (El-Najjar et al., 1976). Other factors may have also included non-dietary conditions. One example, given in Mays (1998), is that disease, such as gastro-intestinal infections may cause diarrhoea, and as food passes quickly through the stomach, the required nutrients are not taken up by the body, which creates an iron deficiency. The exact aetiology of the condition is largely unknown, but it is thought to form following inflammation and haemorrhage as a result of numerous conditions, such as rickets or tuberculosis (Lewis, 2004). Gjerdrum et al. (2008) states that scalp infections and sub-pericranial hematomas may produce lesions resembling porotic hyperostosis.

Cribra orbitalia

Cribra orbitalia has been associated with anaemic conditions for a long period of time (White and Folkens, 2000). Cribra orbitalia is characterised by small lesions on the orbital roof. Aufderheude and Rodriguez-Martin (1998) state that the lesions are generally found in the anterolateral section of the orbital cavity and will most likely affect both orbits. It has been found to be geographically and temporally variable, being caused by a number of factors, including chronic iron deficiency, inflammation, gastro-intestinal and parasitic infections (Carlson et al., 1974, Cybulski, 1977, Wapler et al., 2004). These lesions may also have been caused by osteoporosis and post-depositional erosional forces (Wapler et al., 2004). Gjerdrum et al. (2008) states that macroscopically orbital hematomas may be visually indistinguishable from marrow hypertrophy, which is an effect of cribra orbitalia. The hematomas can be caused by trauma or inflammation of the eye. Therefore, whilst the presence of cribra orbitalia does not necessarily mean that the individual had anaemia, it is more than likely that they suffered a chronic condition.

4.1.9.2 Iron Withholding Reactions in Ban Non Wat and Noen U-Loke

In adults, the effects of iron withholding would have become more obscured if the condition took place in childhood. The lesions on the skull and orbital sockets would have had time to heal and have indications of bony remodelling. It is also possible that the diploë may have reduced in size. Where the skull is complete and has not fractured during deposition, it is difficult to determine if there has been any diploic thickening. Porotic hyperostosis and cribra orbitalia were recorded following Buikstra and Ubelaker (1994):

Degree:

a. Barely discernible
b. Porosity only
c. Porosity with coalescence of foramina, no thickening
d. Coalescing foramina with increased thickness

Activity:

a. Active at time of death
b. Healed
c. Mixed reaction: evidence of healing and active lesions

The results from Ban Non Wat are based on macroscopic and low power microscopic examination of the skull and orbital sockets. No radiographic methods have been used to determine if there has been a thickening of the skull vault or the orbits.

At Ban Non Wat, nine individuals exhibited healed lesions on the skull, none of which had lesions visible in their orbits (Table A 21 [p. 417] and Table A 22 [p. 419]). However, none of the individuals who had cranial porosity had complete orbits. It is difficult to unequivocally determine if the nine individuals had porotic hyperostosis as cranial thickness could not be determined in most cases. The porosity in each case was not considered to be severe. These discrete areas of pin-point holes represent healed lesions, and may represent survivors of an anaemic condition. With the lack of any indication of diploic thickening, a diagnosis of porotic hyperostosis could not be made. As a result, no individuals in Ban Non Wat were identified as having a haematopoietic childhood condition.

No individuals from Noen U-Loke were identified as having porotic hyperostosis or cribra orbitalia (Table A 23 [p. 423]). The Noen U-Loke sample is of poor quality, and concretions encased many skulls and reduced the integrity of orbital vaults making identification of any anaemic reaction difficult.

4.1.9.3 SEAHI Methodology – Childhood cranial and orbital lesions

Whilst it is acknowledged that the causes of these reactions are wide and varied, this attribute has been included due to its connection to childhood afflictions. The sample consists solely of adult skeletons and any lesions found are likely to be healed and indicate survival. There are difficulties in identifying healed anaemic reactions in adults, as post-depositional erosion and normal bone structure may mimic the lesion. Therefore, to be identified, the pitting needs to be of a severe grade, but healed. The Noen U-Loke database recorded cribra orbitalia and porotic hyperostosis descriptively within a general pathology sub-database, and had to be interpreted. The Ban Non Wat database was set up to specifically record any childhood cranial and orbital lesions reactions separately from general pathology. The scoring system can be found in Table 19. The cranial and orbit are scored separately (scoring between 0 and 50 each) and are then combined for the attribute score.

4.1.10 Infections/Other Pathologies

Whilst there are hundreds of classified diseases, only a portion physically affect the chemistry of the human skeleton (WHO, 2007). The exact cause of death cannot be ascertained from most skeletons, as many acute conditions do not cause any skeletal changes. However, bones can be affected by infection and chronic conditions. The bone reacts in three ways in response to these conditions – resorption, deposition or a combination of both (Mann and Hunt, 2005). Where there is resorption by osteoclasts, a lytic lesion is formed, while osteoblastic lesions are depositional lesions. Bone abnormalities take many forms and their morphology can inform on the type, speed and stage of the condition. For example, where lesions are found lined with cortical bone and well-defined margins, the condition is generally slow and chronic, while projecting spicules of bone are suggestive of a rapid and aggressive condition (Lovell, 2000).

The exact cause of death cannot be ascertained from most skeletons, as many acute conditions do not cause any skeletal changes. There are numerous diseases and conditions that can be identified on skeletal materials, but some are geographically and ethnically restricted (Ortner, 2003).

The periosteal surface, the compact bone or cancellous bone can be affected by infections. The type of infection is often difficult to determine, but some conditions leave distinctive marks. An understanding of the various conditions is required to understand the lesion patterns on bone and the pattern of lesions can assist in the diagnoses of the condition. A number of conditions have relatively unique skeletal indicators, such as treponemal infections (Buckley and Dias, 2002), whilst others can affect the entire skeleton, such as a metabolic bone disease, for example rickets (Lovell, 2000). Identification of conditions depends on the "…accurate differential diagnosis of diseases" (Ortner, 2003: 37) as well other variables. When making diagnoses it is important to conduct a differential diagnosis (Tayles, 1996, Belcastro et al., 2005, Canci et al., 2005). All possible causes of the lesion need to be included in the assessment, which can then lead to a selection of conditions that correspond closest to the lesion. By looking at other factors, such as location and environment, other conditions may also be excluded.

It is recognized that not every condition or disease is visible, and those that are provide valuable interpretations of health of an individual and population. As advances in research conducted on diseases and their effects on the skeleton, as well as further investigation of unknown pathological lesions found on archaeological skeletons, there will be conditions not previously identified in archaeological contexts that will able to be identified (Ortner and Mays, 1998, Nakai et al., 2002, Pinheiro et al., 2004). For example, Ortner and Mays (1998) identified a series of features that are present in sub-adult sufferers of rickets, although many of these could be recognized as other conditions. Whilst the identification of pathology on skeletal materials is a difficult task, our present knowledge of lesions and their causes is important in assisting the bioarchaeologist in understanding not only the health of the individual, but also their lifestyle and society itself.

It is more likely, however, that indicators of infection found on the bone will not provide a name to a definitive condition. It is more likely that a skeleton found in an archaeological context will exhibit signs of infection that cannot be directly identified. Non-specific lesions include periostitis, although these can be formed as a result of non-infectious means, such as a traumatic or haemorrhagic event. Some conditions possibly present in Southeast Asian populations include osteomalacia, tumours, leprosy, tuberculosis, yaws and malaria (Tayles, 1996, Domett, 2001, Tayles and Buckley, 2004).

Lesions and other bony anomalies found at Ban Non Wat were documented according to the recording standards in Buikstra and Ubelaker (1994). This included recording abnormal bone loss, size and shape. Macroscopic observation and a low-power microscope were used to examine the bones for changes. A basic visual description of the anomaly was also recorded. At Noen U-Loke, pathological changes and anomalies were recorded according to the terminology establish in Ortner (2003).

Results – pathological conditions in Ban Non Wat and Noen U-Loke

Table A 23 (p. 423) lists the pathological anomalies found at Noen U-Loke. Of these only one (NUL87) is not included in the Southeast Asian Health Index due to the extremely poor condition of the skeleton and the lack of information the skeleton could provide. At Ban Non Wat, there was evidence of bony anomalies in a number of individuals (Table A 24 [p. 425]). Because the purpose of this study is to test a method for determining relative health, a differential diagnosis for each individual was attempted. The assessment of bony anomalies at Ban Non Wat, however, can only be considered preliminary. A brief assessment of bony anomalies at Ban Non Wat can be found in Table A 25 (p. 448). Most of the pathological lesions are attributed to a non-specific soft tissue infection and trauma. No specific diseases were diagnosed.

4.1.10.1 SEAHI Methodology – Infections/other pathologies

An attribute is required to encompass the range of different pathologies that are visible as lesions on the skeleton. In the WHHI, the attribute is sub-categorised into two sections: the tibia and other long bones. That method places too much emphasis on lesions on the tibia and ignores lesions on non-long bones. In the SEAHI, all the bones are considered equally (Table 19). The gradings include assessments of periosteal and lytic lesions, and their effects on a bone. The use of both types of lesions allows for a wider range of conditions to be incorporated into the health index. In addition, where a skeleton shows signs of a systemic disease, the lowest grading is given due to the nature of systemic disease, such as leprosy or tuberculosis. Any osteomyelitic reactions are also given the lowest grading as it is an extreme form of inflammation (Ortner, 2003). Where a skeleton does not show signs of systemic disease, but a number of bones have lesions, the score is based on the bone/s with the most severe lesions. The pathologies from Noen U-Loke and Ban Non Wat samples were recorded descriptively. The only way to score any lesions found is to examine each researcher's description of pathologies.

Providing a scoring system on the severity of lesions is difficult. During the data recording stage, a standardized format was used to illustrate skeletal abnormalities, which also allowed a straight-forward description. No identification of cause of the abnormality was attempted at the recording stage. Photographs were taken.

Limitations to data recording were that the range of normal variation amongst prehistoric Southeast Asian populations was unknown at the beginning of the data recording. This was compounded by the severe concretions on many skeletons, especially those of the Iron Age period. In order to minimize observer error, all perceived skeletal anomalies were double checked by more experienced bioanthropologists.

Whether or not a lesion is healed also influences the score an individual receives, which is not considered in the WHHI. Logically, if a lesion is healed at the time of death, then the person has survived the affliction and is therefore healthier than a person with an active lesion at death. However, not to unduly place emphasis on the health at death, the differences between active and healed lesions is not great. The scoring system can be found in Table 19.

4.2 Calculation of the SEAHI

The SEAHI scoring system is much simpler than that of the WHHI. The WHHI methodology requires each individual to be compared against a reference population, essentially the estimated life expectancy of a synthetic population derived from synthetic life-tables. The use of a synthetic population could, in fact, provide a false measure. The SEAHI provides an easily reproducible, comparable ranking system that can be used in prehistoric Southeast Asia, where individuals can be assessed as well as sub-groups and populations.

There are eight health attributes in this health index. The minimum number of attributes required in order to assess an individual has been set at six. This is adequate in order to indicate health for an individual and, at the same time, allow a score to be obtained for the greatest number of individuals within the total sample. For example, numerous individuals will not have a score for long bone length due to the delicate nature of bones found in archaeological contexts in Southeast Asia, but may have one for enamel hypoplasia, also a growth indicator. The poor condition of bone may also hinder the identification of joint disease. In order for the health index to be usable, some flexibility is needed.

As the attributes are calculated using different methodologies, the results can only be directly compared to each other if they are standardized. It is statistically unsound to directly compare attributes calculated using different methodologies as they have different distributions, central tendency and variability. z-scores enable this standardization. Based on the population mean and standard deviation of each attribute, the individual is scored based on the number of standard deviations they are from the mean for that attribute. This provides one with directly comparable data between attributes. The z-scores from each attribute are summed and then averaged for each individual. The mean is set at zero, which can be visually awkward as there are negative values. Therefore, the z-score is modified to have a mean of 50 using the T-Score method (Diekhoff, 1992). This is seen as

$$z = \frac{(x - \bar{x})}{s}$$

Where x is the score, $\bar{x}$ is the mean of the distribution and s is the standard deviation of the distribution. This provides a score with a mean of zero. This score is then modified to have a mean of 50:

$$\text{Mod } z = z \times 10 + 50$$

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Table 19: Scoring methodology for SEAHI.

AGE AT DEATH		DENTAL HEALTH		TRAUMA		LONG BONE LENGTHS		ENAMEL HYPOPLASIA		DEGENERATIVE JOINT DISEASE		CHILDHOOD ORBITAL / CRANIAL LESIONS		OTHER PATHOLOGIES	
Young adult	0	**Alveolar bone health (25%)**		**No trauma**	20	**Long bone averages**		**0-1 Tooth affected**	100	**No sign of joint disease**	14.2	**Crania**		**No infectious lesions.**	100
Mid adult	50	Periapical cavity	0	**Moderate evidence of trauma**	10	< + 1 Std Dev	100	**2-3 Teeth affected**	50	**Early signs of joint disease**	7.1	No lesions	50	**Slight, small discrete patch(es) of periosteal reaction, small osteoclastic/ lytic lesion. Healed lesion.**	85.71
Older adult	100	Periodontal cavity or infrabony pocket	12.5	**Severe evidence of trauma**	0	Average (between +1 and -1 Std Dev)	75	**>3 Teeth Affected**	0	**Signs of well-progressed disease**	0	Severe healed pitting – small to moderate size	25	**Slight, small discrete patch(es) of periosteal reaction, small osteoclastic/ lytic lesion. Active lesion.**	71.43
		No cavity	25			> - 1 Std Dev	50			For 7 Areas: • Shoulder • Elbow • Wrist • Hip • Knee		Severe healed pitting covering large area	0	**Moderate periosteal reaction involving less than one-half of the bone, moderate lytic lesion. Healed lesion.**	57.14
		Caries/ AMTL (75%)		For 5 Areas: • Upper limb • Lower limbs • Face • Crania • Torso		> -2 Std Dev	25					**Orbits**		**Moderate periosteal reaction involving less than one-half of the bone, moderate lytic lesion. Active lesion.**	42.86
		1 minus the ratio of (Sum of AMTL + Caries): (Sim of Teeth and AMTL) x 75%	(=/<75)			>-3 Std Dev	0			• Ankle • Inter- Vertebral body		No lesions	50	**Large amount of periosteal reaction involving more than one-half of the bone, large lytic lesion. Healed lesion.**	28.57
												Severe healed pitting – small to moderate size	25	**Large amount of periosteal reaction involving more than one-half of the bone, large lytic lesion. Active lesion.**	14.29
												Severe healed pitting moderate to large in both orbits	0	**Osteomyelitis or evidence of systemic disease. Healed and active lesions.**	0

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The modified z-score is the SEAHI score for each individual skeleton. As the modified z-score is based on the distribution mean, if additional data, for example from other sites, is added to the distribution, all modified z-scores need to be recalculated. The modified z-scores are a ranking system. A score of 55 as opposed to 45 does not mean that the individual with 55 was ten points healthier, only that they had a ‘healthier’ overall life.

After obtaining individual scores in the SEAHI, there is the potential to produce indices that can then be averaged in sub-groups, such as males and females, or the whole population sample to be compared with another population. Steckel et al.(2002b) argue that by using individual data, and not including all the skeletal data from incomplete individuals, that averaging would be erroneous and biased. However, the excavation of cemetery sites initiates this bias, as the majority of sites are not fully excavated, they are only sampled. Biases are inherent. The WHHI cannot look at sub-groups such as sex, only at populations, which is limiting.

4.2.1 Limitations

This methodology can be retrospectively used on archaeological skeletal remains that have been previously analysed. Unfortunately, as each osteological investigation is different, so may be the methods used to obtain data. For example, in determining dental health using the SEAHI, one of the parameters is the presence or absence of infrabony pockets. In Southeast Asia, previous investigations are unlikely to have collected data on this attribute. In such cases, the best option would be to remove these attributes out of the health index and only have them in where they have been recorded in all samples. In addition there is also the issue of inter-observer error. This can be problematic in any comparative study. The use of presence/absence on a number of attributes lessens the impact of inter-observer error (see Jacobi and Daniforth, 2002). As more sites are investigated and further skeletal data are gathered and added to the index, all of the scores for each individual are required to be recalculated.

5 HEALTH INDEX RESULTS

5.1 The SEAHI and components – Results

This chapter details the results of the Southeast Asian Health Index for Ban Non Wat and Noen U-Loke. Table A 26 (p. 453) details the results of the SEAHI assessment of the Ban Non Wat and Noen U-Loke samples. The results of each component of the SEAHI are examined separately as well as the overall SEAHI scores. The individual attributes, such as long bone lengths and enamel hypoplasia have their own individual scores. Individuals and groups will first be compared using the scores for each single attribute. Then the attributes are converted into z-scores and combined to produce an overall SEAHI score. Correlation analysis of health is also conducted prior to a discussion of the results in Chapter 5.2.

For the SEAHI, the z-score is modified (as per T-Score method) so that 50 is the mean. The SEAHI immediately shows if an individual is above or below the mean health score for that sample. Figure 25 shows the pattern of SEAHI scores for individuals in Ban Non Wat and Noen U-Loke from highest to lowest. Scores ranged from 38 to 56. As 50 is the mean, there are a number of individuals well below the mean.

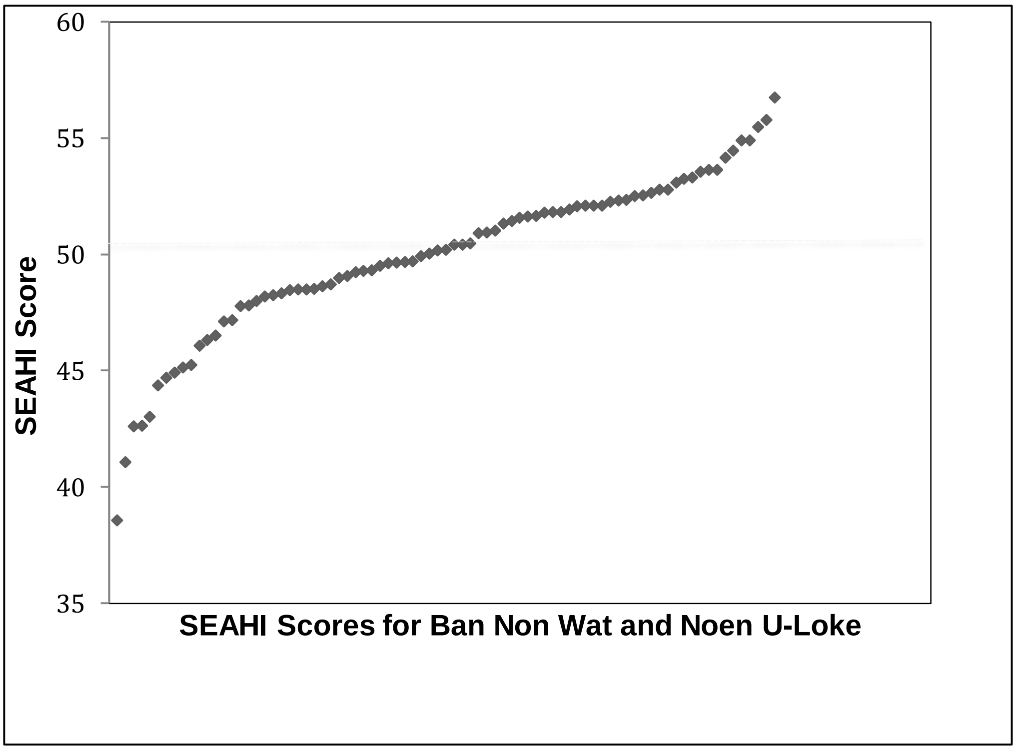

Figure 25: SEAHI of individuals in Noen U-Loke and Ban Non Wat in order of highest score to lowest - mean is 50.

5.1.1 Dental Disease

Overall, Ban Non Wat had poorer dental health than Noen U-Loke based on the mean dental disease score (Figure 26). The difference between the sites is not statistically significant ($t[78]= -0.416$, $p>0.05$). Figure 27 shows that Noen U-Loke had two individuals that were well outside the norm, but the majority of Noen U-Loke individuals had a high dental disease score (above 90).

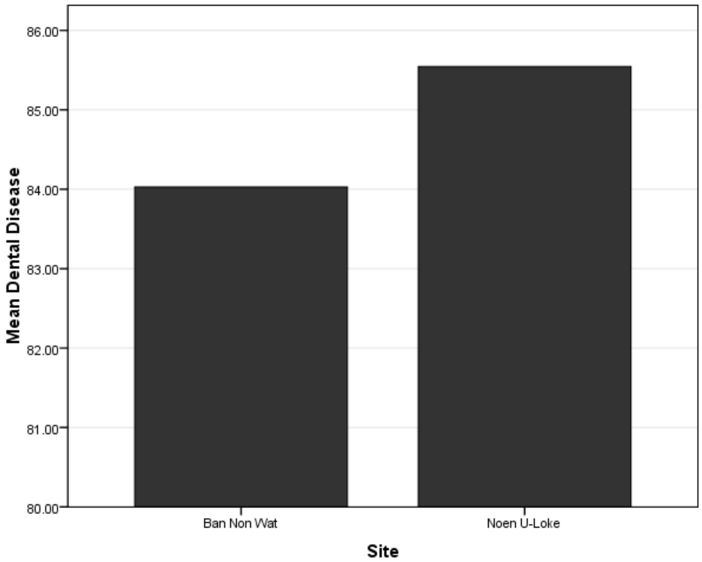

Figure 26: Dental Disease score mean by location.

Figure 28 graphically shows a large difference in the mean for the dental disease score by age at both sites between older adult and young/mid adults. This is statistically significant ($F[2,77]=20.976$, $p<0.05$). Further analysis with a Tukeys HSD test identifies older adults as being significantly different compared to younger age groups. The pattern is the same for both sites. This result is to be expected as dental conditions become more prevalent with age due their inability to remodel as bone can as well as other factors. The range of dental disease scores in older adults at Noen U-Loke include two outliers (Figure 29), but the majority of individuals scored close to 70 or over, whereas at Ban Non Wat, the range was larger.

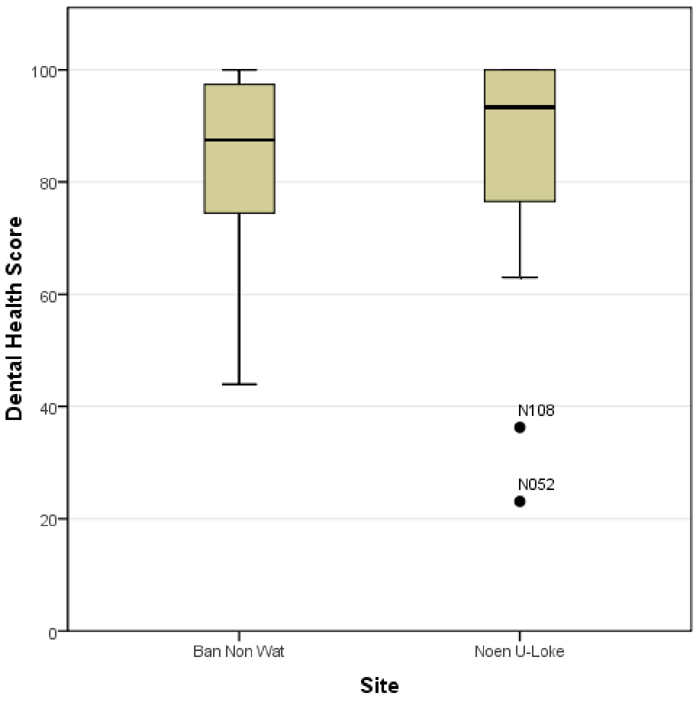

Figure 27: Boxplot of dental disease score according to location.

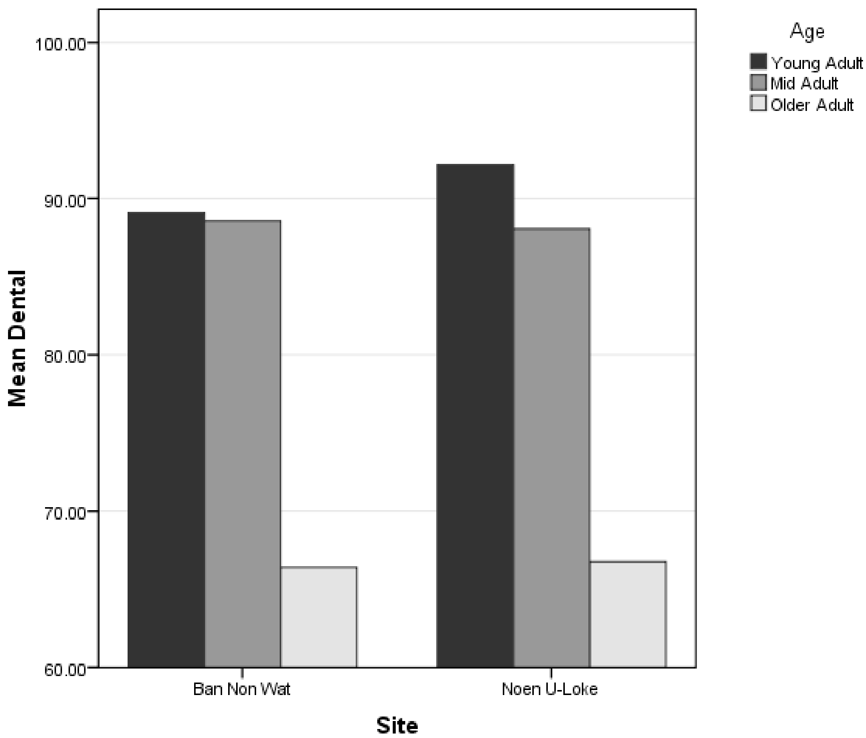

Figure 28: Mean of Dental Disease score by age at Ban Non Wat and Noen U-Loke.

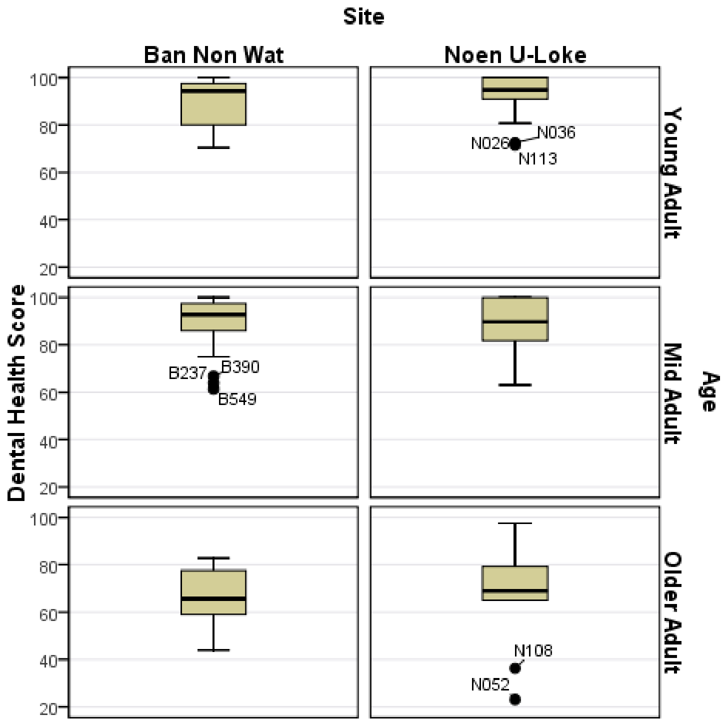

Figure 29: Boxplot of dental disease scores according to location and age group.

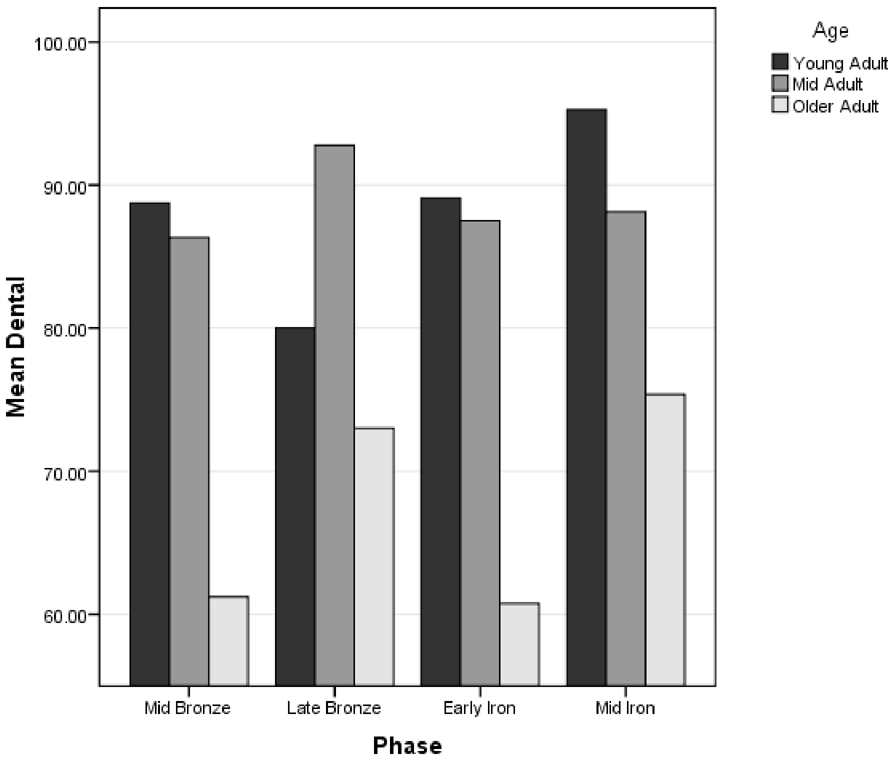

Figure 30: Dental disease mean score according to phase and age.

The patterning amongst the different phases is generally similar in relation to ages, except for the Late Bronze Age (Figure 30). During this phase, the young adults have poorer dental health than mid adults. This may indicate a change in diet, but if this was the cause, then all age groups would be affected. Figure 31 clearly shows that older adults in the Early Iron Age have a large range of dental disease scores and that all of the young adults in the Late Bronze Age had a score of 80. The data shows that there is only one young adult in the Late Bronze Age sample. There are no statistically significant differences between young adults in the four phases ($F[3,26]=1.489$, $p>0.05$). This result is replicated for mid adults ($F[3,29]= 0.305$, $p>0.05$) and older adults ($F[3,13]=0.707$, $p>0.05$). However, there are statistically significant differences between the three age groups in the Mid Bronze Age ($F[2,10]=4.627$, $p<0.05$), as well as the Early Iron Age ($\chi^2[2,\underline{N}=32]=7.901$, $p<0.05$) and the Mid Iron Age ($F[2,23]=5.235$, $p<0.05$). There is no difference between the different age groups in the Late Bronze Age ($F[2,6]=4.954$, $p>0.05$), although this may be a result of the small sample in this phase. The statistical differences appear to be driven by the scores of the older adults, which shows that their survival into older adulthood at these two sites is accompanied by increased dental disease, which is to be expected.

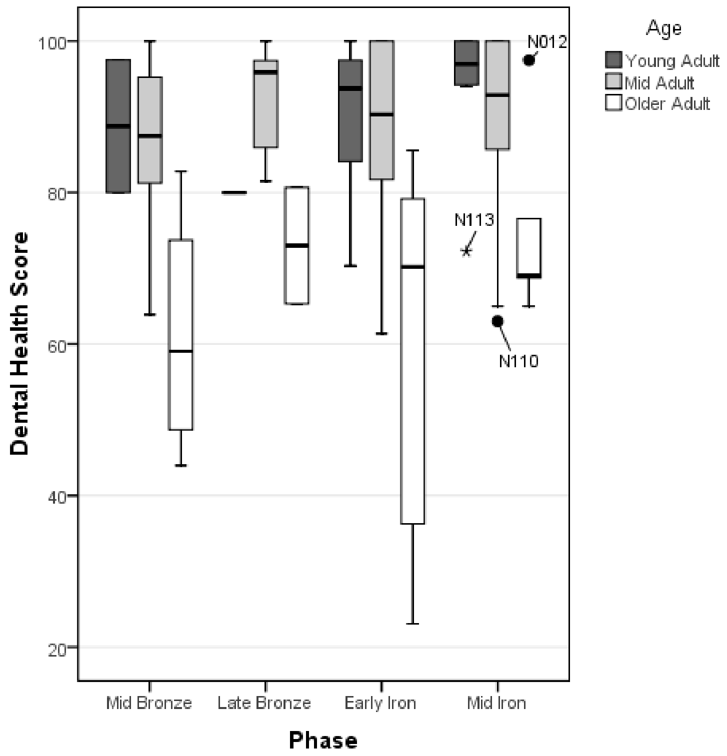

Figure 31: Boxplot of dental disease scores according to age and phase.

Females have poorer dental disease scores on average (Table 20), although there is no statistical difference between the sexes (t[66]=1.961, p>0.05). Mean dental score of males and females at Ban Non Wat are similar but distinctly different at Noen U-Loke (Figure 32). The difference between males and females at Noen U-Loke is statistically significant (t[33]=2.583, p<0.05). Females had poorer dental health than males overall at Noen U-Loke. There is no difference statistically between males and females at Ban Non Wat (t[31]=0.038, p>0.05). There are no differences between males from Noen U-Loke and males from Ban Non Wat (t[33]=-1.947, o>0.05). Interestingly there is no difference between females of Noen U-Loke and those from Ban Non Wat (t[31]=0.895, p>0.05). This may show that there are dietary and dental hygiene issues amongst the female population of Noen U-Loke, whilst it appears that males had improved conditions. Examination of the range of scores (Figure 33) shows that Noen U-Loke females have two outliers that may be influencing the results, although the median for males and females reinforces the difference between them.

Table 20: Mean dental disease score of males and females from combined Noen U-Loke and Ban Non Wat sample.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Dental	Male	35	86.8334	13.57463	2.29453
	Female	33	79.1423	18.51848	3.22365

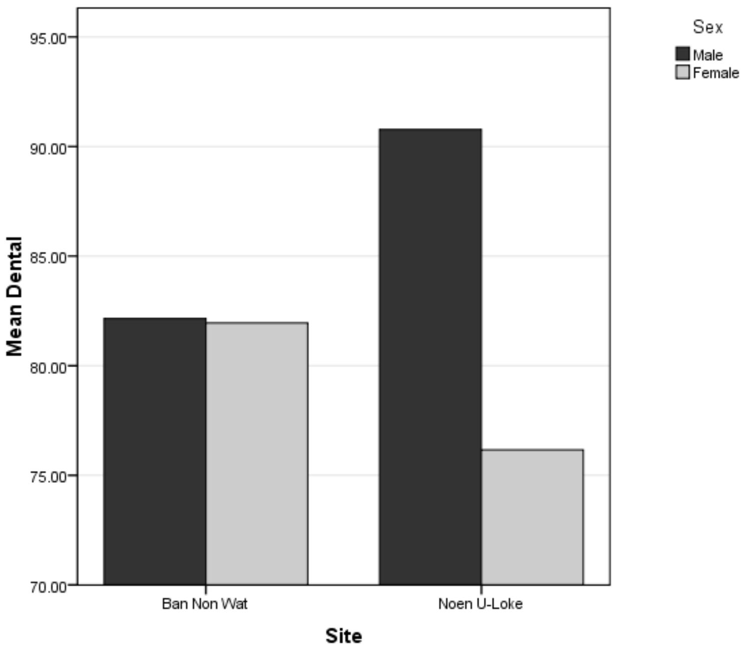

Figure 32: Mean dental disease according to site and sex.

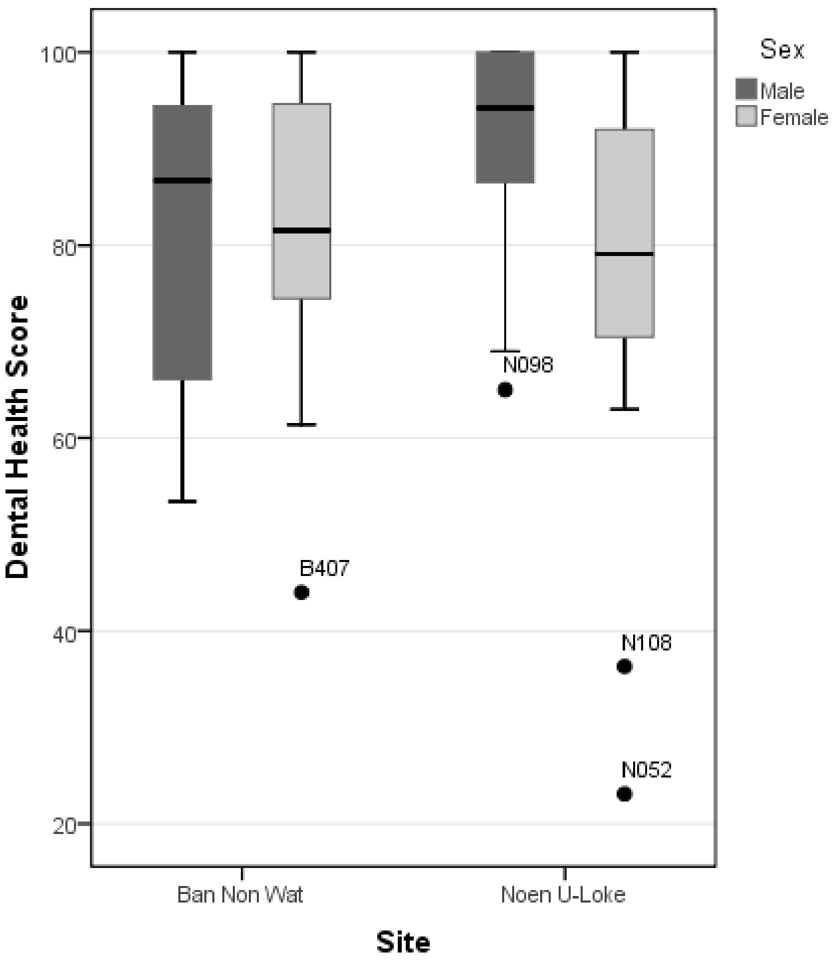

Figure 33: Boxplot of dental disease score according to location and sex.

Dental health generally improves over time, with the exception of the Early Iron Age (Figure 34). There is no significant difference between the phases ($F[3,76]=1.307$, $p>0.05$). The Early Iron Age score for dental disease at Noen U-Loke has highly influenced the overall score (Figure 35). However, the difference between Ban Non Wat and Noen U-Loke in the Early Iron Age is not statistically significant ($t[33]=1.010$, $p>0.05$). When the range and median on each phase is examined, it shows a gradual improvement in dental health through time (Figure 36). The boxplot also shows that the Early Iron Age has outliers, which are from Noen U-Loke. When the sites are placed within phases, however, Noen U-Loke continues to have a lower score seen in the median in the Early Iron Age (Figure 37).

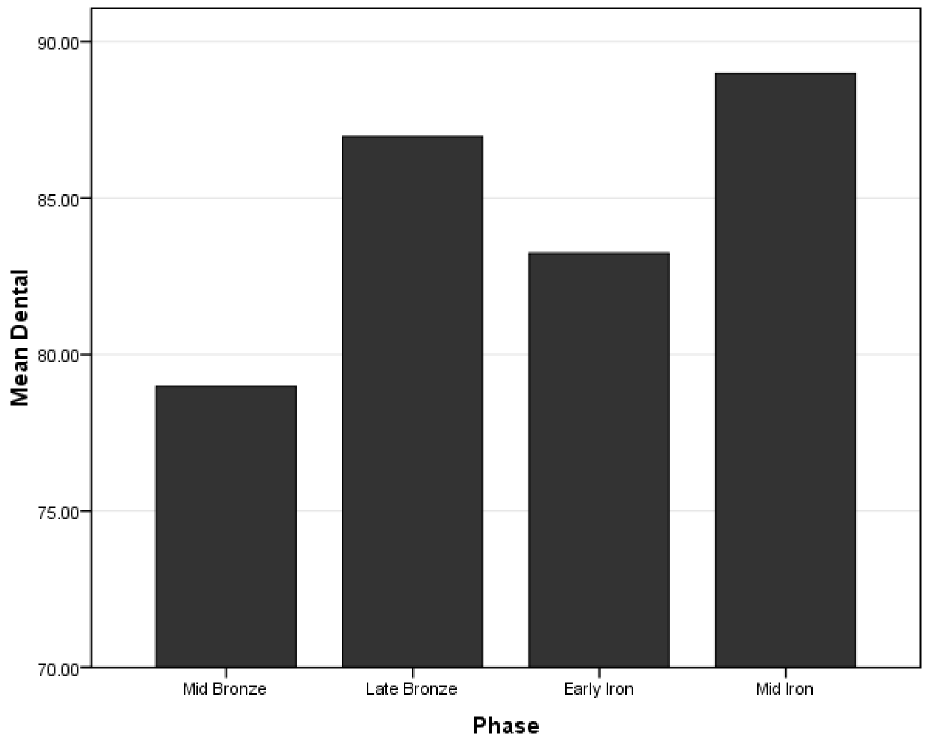

Figure 34: Mean dental disease according to phase.

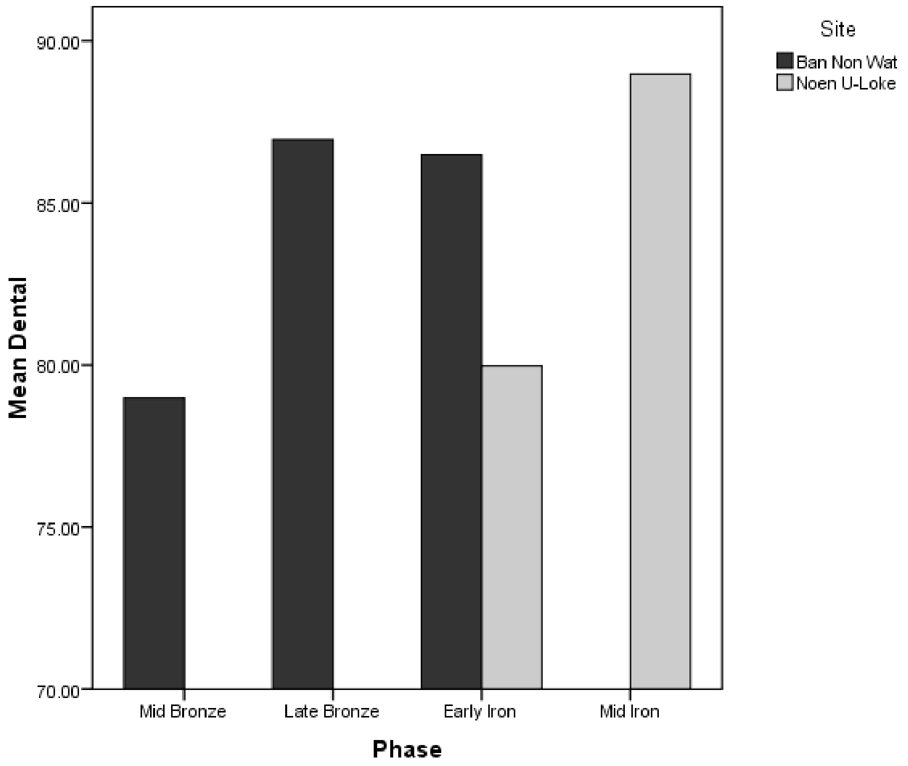

Figure 35: Mean dental disease according to phase and location.

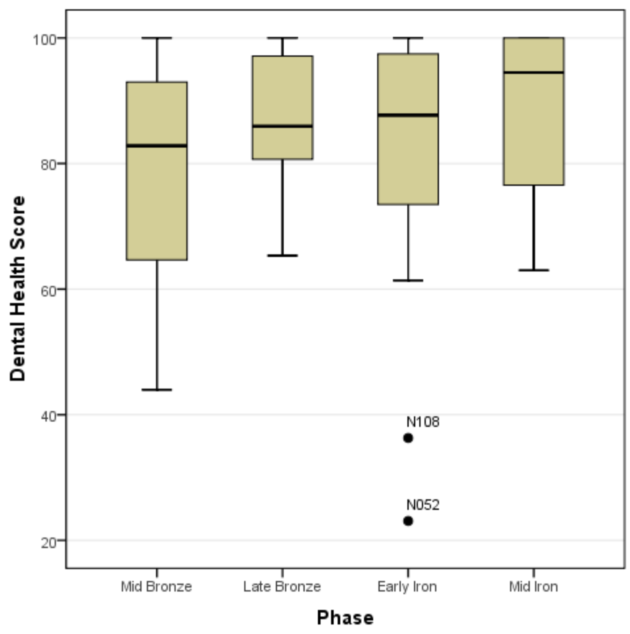

Figure 36: Boxplot of dental disease according to phase.

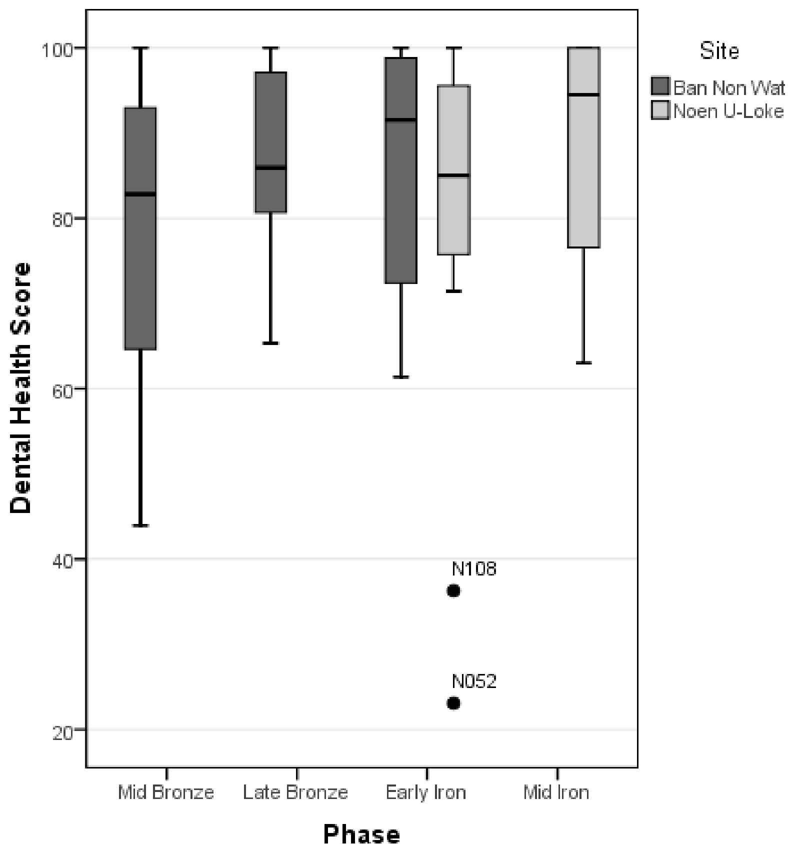

Figure 37: Boxplot of dental disease according to location and phase.

The Iron Age is defined by a broader difference in dental disease between males and females (Figure 38). There is no statistical difference between the males ($F[3,31]=2.026$, $p>0.05$) or between the females across the phases ($F[3,29]=0.280$, $p>0.05$). There is a statistical difference between males and females in the Iron Age (combined Early and Mid Iron Age) ($t[45]=2.630$, $p<0.05$), which is not evident in the Bronze Age ($t[19]=-2.97$, $p>0.05$). Female variability, especially in the Early Iron Age, is wide ranging (Figure 39). The pattern suggests that male dental health improved over time and female dental health did not, and this shows that there is a definite disparity between the males and females of Noen U-Loke only.

There is little disparity between the sexes within each age group (Figure 40), although the median scores shows a minor differences from the mean scores in older adults (Figure 41). There is no statistical difference between the mean scores of males and females that are young adults (χ^2 [15,N=25] =15.330, $p>0.05$), mid adults ($t[24]=0.559$, $p>0.05$) or older adults ($t[15]=0.504$, $p>0.05$).

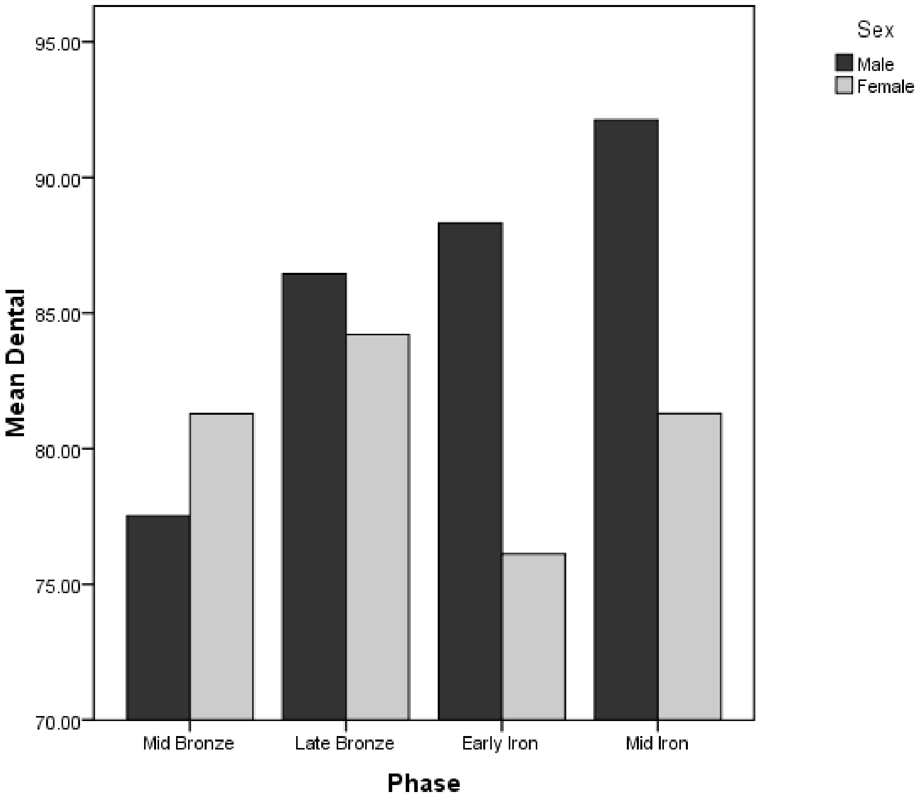

Figure 38: Mean dental disease score by phase and sex.

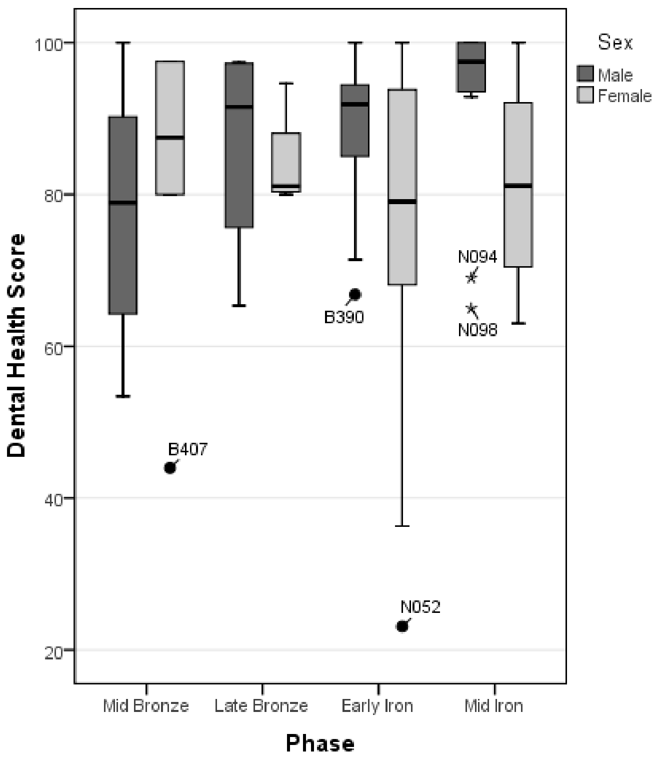

Figure 39: Boxplot of dental disease score according to phase and sex.

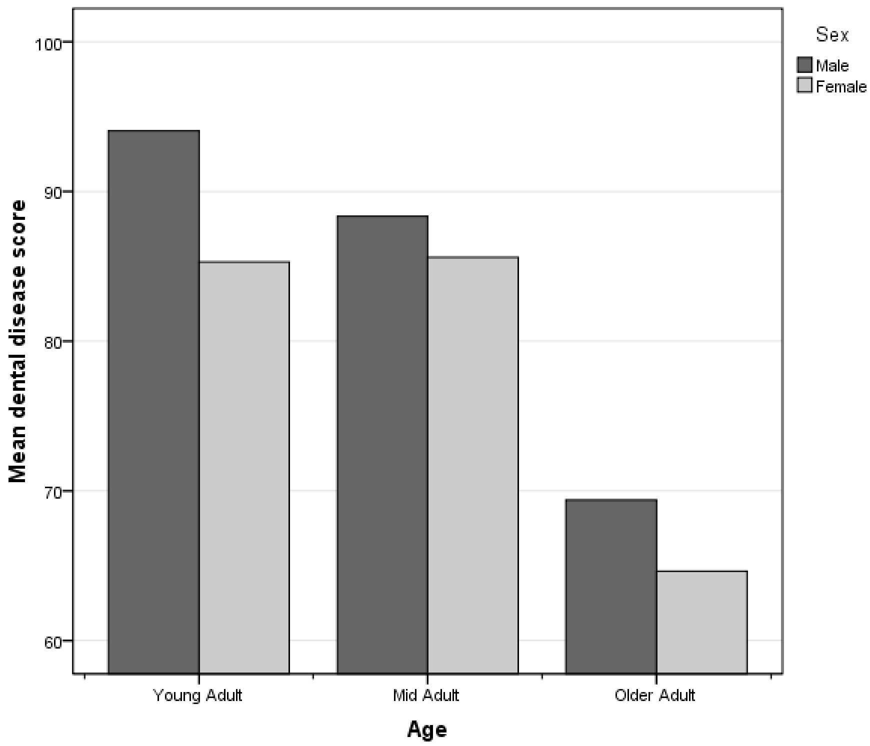

Figure 40: Mean dental disease score according to sex and age.

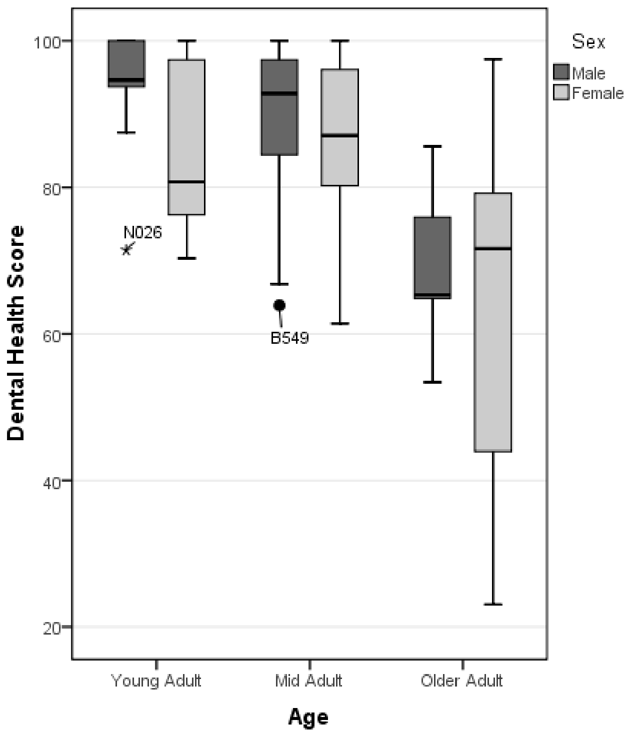

Figure 41: Boxplot of dental disease according to age and sex.

5.1.2 Trauma

Evidence of trauma in both samples was minimal. There is little difference in mean trauma score according to location (Table 21), therefore there is no distinction between Ban Non Wat or Noen U-Loke in terms of trauma. This suggests that activities and levels of violence are similar at both sites.

Table 21: Comparison of mean trauma score according to location.

SITE	MEAN	N	STD. DEVIATION
Ban Non Wat	97.11	38	6.111
Noen U-Loke	97.67	43	6.487
Total	97.41	81	6.280

The combined mean for trauma according to age is shown in Figure 42. A Kruskal-Wallis test was undertaken (χ^2 [2,N=81]=6.012, $p<0.05$) showing a significant difference amongst the different age groups. A Tukey HSD test, however, did not show any significant difference between any specific age groups. When the locations are separated, the overall combined pattern appears to be directed by the pattern at Ban Non Wat (Figure 43). A Kruskal-Wallis test was calculated for age groups at Ban Non Wat and no statistical difference was found

(χ^2[2,$\underline{N}$=38]=4.675, p>0.05). The same result was identified for Noen U-Loke (χ^2[2,$\underline{N}$=43]=2.076, p>0.05). A comparison of young adults between Ban Non Wat and Noen U-Loke (Figure 44) showed no significant differences (t[28]=0.648, p>0.05). The same result was obtained for mid adults (t[32]=-0.636, p>0.05) and older adults (□^{2} [2,N=17] =2.951, p>0.05).

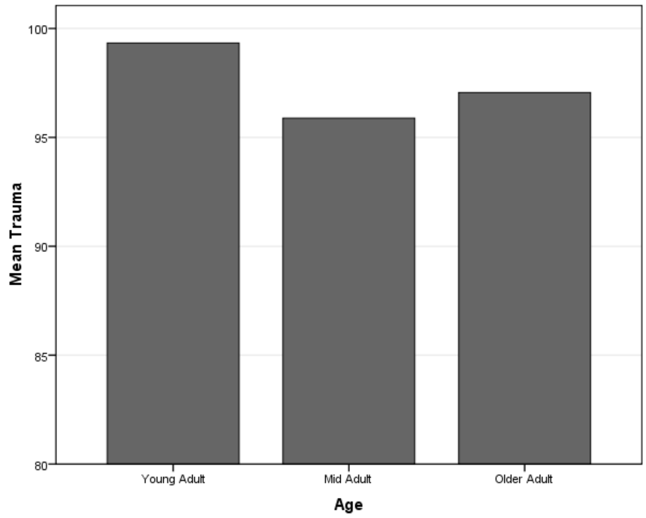

Figure 42: Mean trauma score according to age in Ban Non Wat and Noen U-Loke.

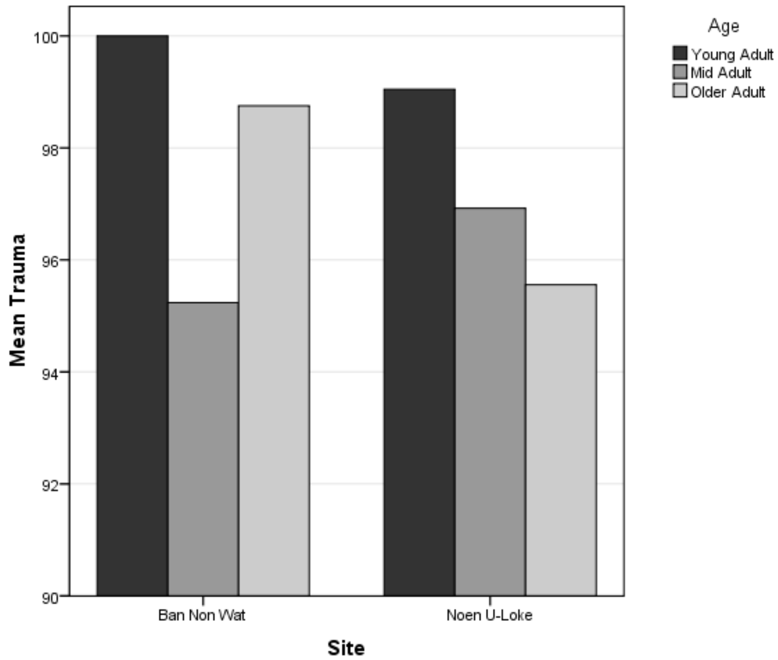

Figure 43: Mean trauma scores according to age and location.

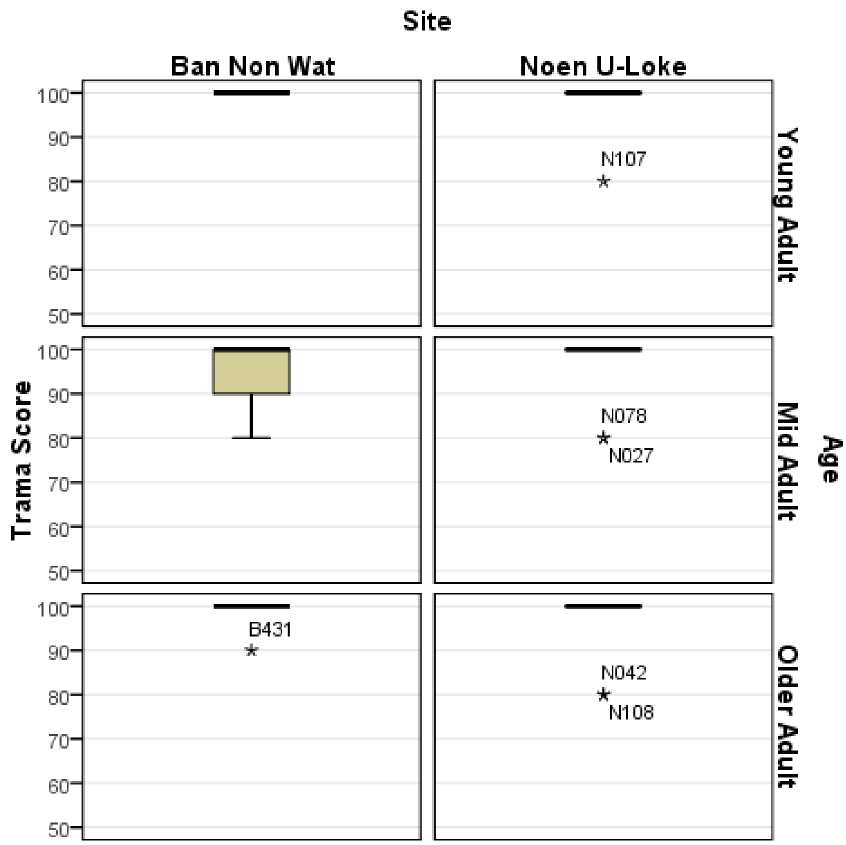

Figure 44: Boxplot of trauma scores according to location and age.

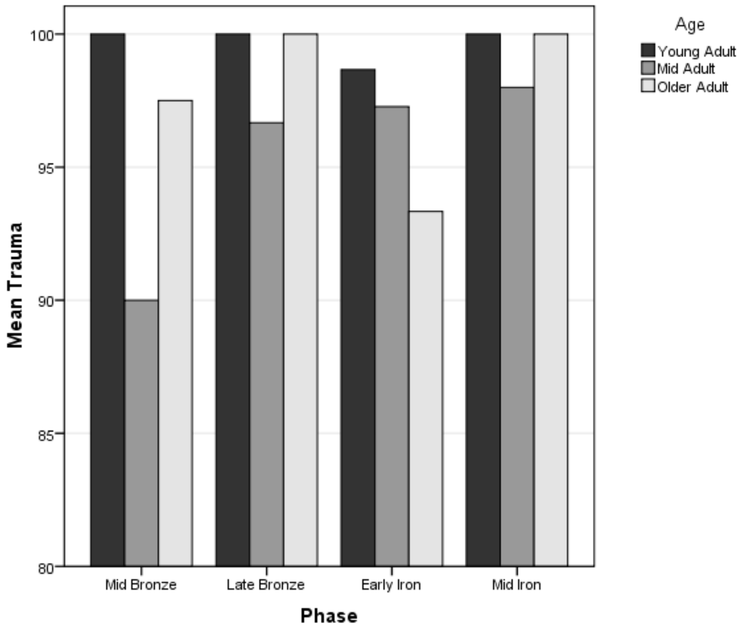

Figure 45: Mean trauma according to age and phase at Ban Non Wat and Noen U-Loke.

The Early Iron Age is the only phase where mid adults have, on average, a better trauma score than older adults (Figure 45). In the Mid Bronze Age, mid adults appear to have a distinctly lower score than younger and older adults, but this is not statistically significant (χ^2[2,N=13]=2.882, p>0.05). The pattern of age trauma scores within the different phases shows that, except for young adults, there is some variability in trauma through the phases (Figure 46). Despite this, there is no statistically significant difference between phases for the different age groups: young adult (F[3,26]= 0.310, p>0.05), (F[3,26]= 0.310, p>0.05); mid adult (F[3,30]= 2.064, p>0.05); and older adults (χ^2[3,N=17]=2.650, p>0.05).

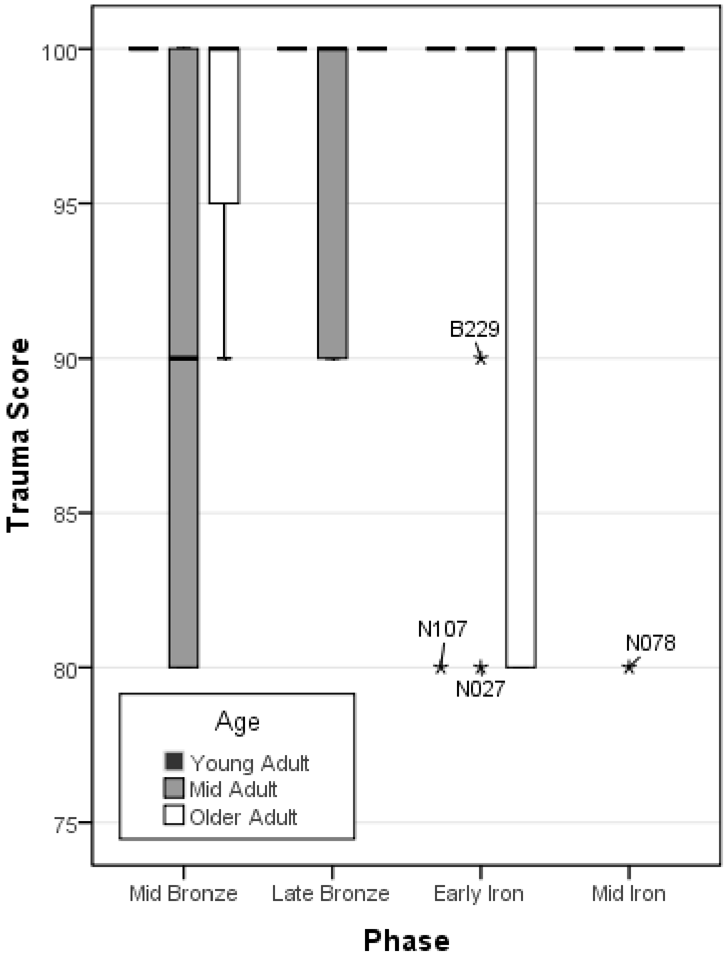

Figure 46: Boxplot of trauma scores according to age and phase.

There is little difference between male and female trauma scores. Males have a slightly lower score than females. The mean of the trauma score for males and females from both Ban Non Wat and Noen U-Loke (Table 22) shows no significant difference (t[66]=-1.042, p>0.05).

Table 22: Mean trauma score for Ban Non Wat and Noen U-Loke.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Trauma	Male	35	96.57	6.835	1.155
	Female	33	98.18	5.839	1.016

The mean trauma scores according to sex were calculated for each of the two sites (Table 23 and Table 24). There is no significant difference between the sexes at either site for mean trauma score (Ban Non Wat $t(31)=-0.624$, $p>0.05$; Noen U-Loke $t(33)=-0.868$, $p>0.05$). When males and females are charted in a boxplot according to site, males in Ban Non Wat appear to be different to males in Noen U-Loke (Figure 47), but this difference is not statistically significant ($t[33]= -0.252$, $p>0.05$). Females in Ban Non Wat are also similar to those in Noen U-Loke ($t[31]=-0.536$, $p>0.05$).

Table 23: Mean trauma score in Ban Non Wat according to sex.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Trauma	Male	16	96.25	6.191	1.548
	Female	17	97.65	6.642	1.611

Table 24: Mean trauma score in Noen U-Loke according to sex.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Trauma	Male	19	96.84	7.493	1.719
	Female	16	98.75	5.000	1.250

Overall, according to the mean trauma score in the different phases, the Mid Bronze Age has a lower mean than the later phases (Figure 48). This difference is not statistically significant ($\chi^2[3,\underline{N}=81]=7.701$, $p>0.05$). Figure 49 shows a boxplot that splits the two sites into phases. The Early Iron Age is the only period where Ban Non Wat and Noen U-Loke can be compared. There is no statistically significant difference between the two sites in the Early Iron Age (□^{2} [2,N=32] =5.333, $p>0.05$).

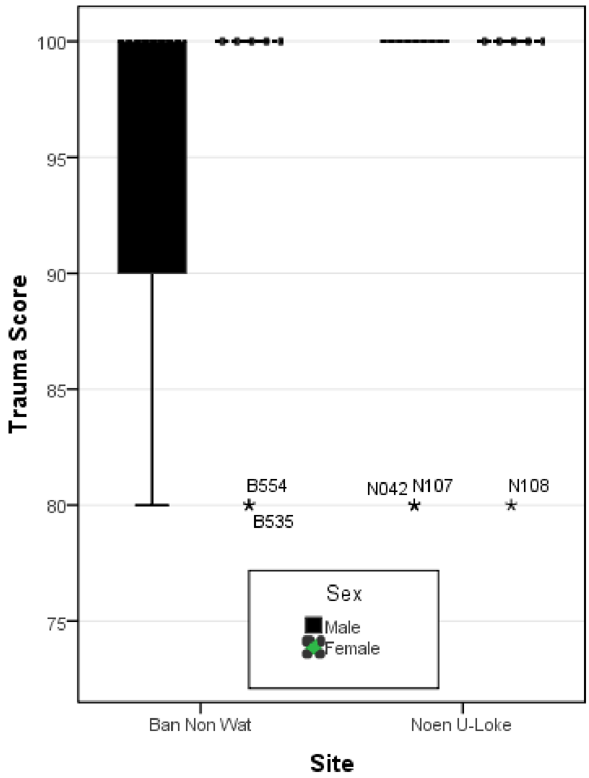

Figure 47: Boxplot of trauma scores according to location and sex.

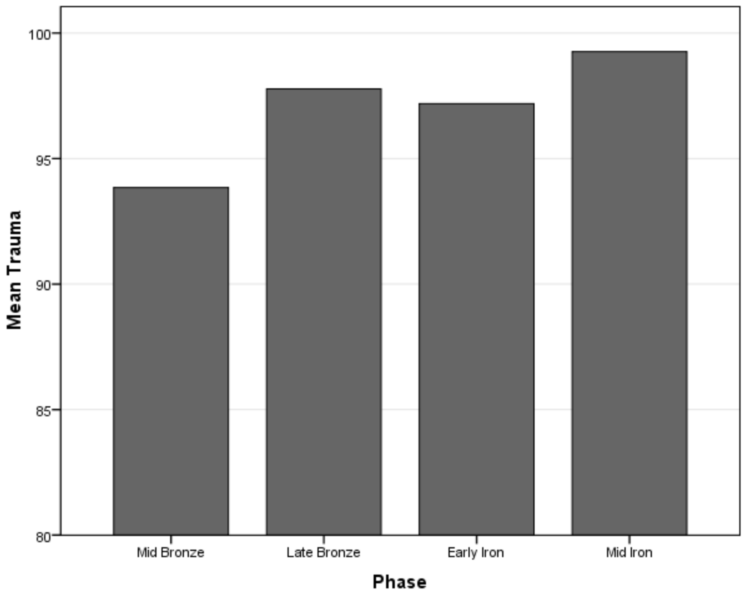

Figure 48: Mean trauma score according to phase at Ban Non Wat and Noen U-Loke.

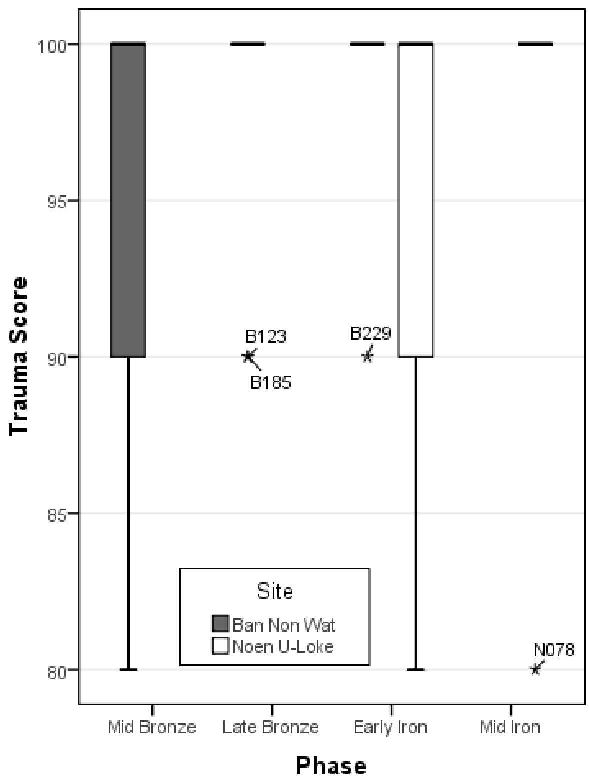

Figure 49: Boxplot of trauma score according to phase and location.

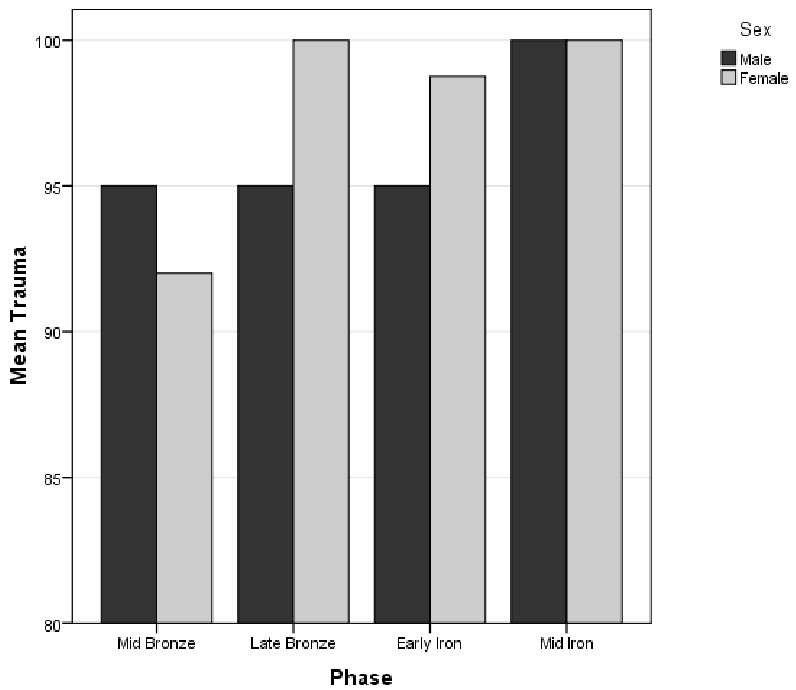

Figure 50: Mean trauma according to phase and sex at Ban Non Wat and Noen U-Loke.

Figure 50 shows mean trauma according to sex and the different phases. There are no apparent patterns for either sex. There is no statistical difference between males in the different phases (χ^2[3,N=35]=5.028, p>0.05) and the same result is found in the female sample (χ^2[3,N=33]=6.920, p>0.05). The Early Iron Age is the only phase where the two locations can be compared. Figure 51 shows a difference between the Early Iron Age male sample in Ban Non Wat and Noen U-Loke, although this difference is not statistically significant Age ($□^2$ [1,N=12] =2.000, p>0.05).

There appears to be little intergroup and intragroup difference in mean trauma score according to age and sex (Figure 52). There is no statistical difference between females in the different age ranges (χ^2[2,N=33]=1.884, p>0.05) or between males (χ^2[2,N=35]=2.907, p>0.05). There is also no difference between males and females in each age group: young adults (t[23]= -0.882, p>0.05); mid adult (t[24]= -0.551, p>0.05); and older adults (t[15]= -0.664, p>0.05).

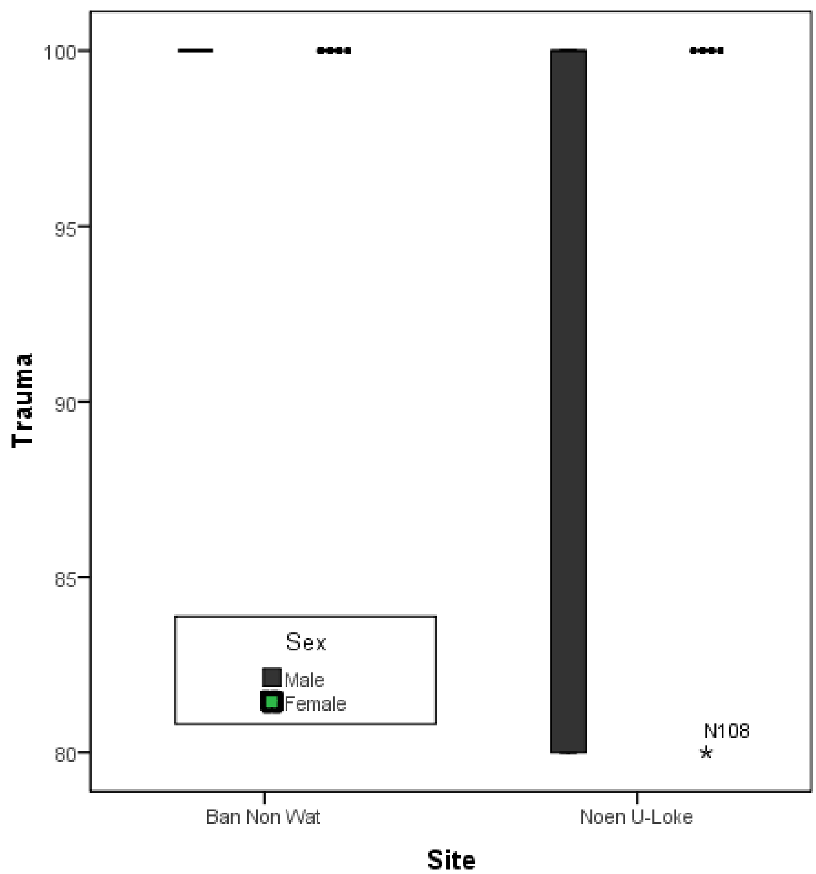

Figure 51: Boxplot of trauma score in the Early Iron Age according to sex and location.

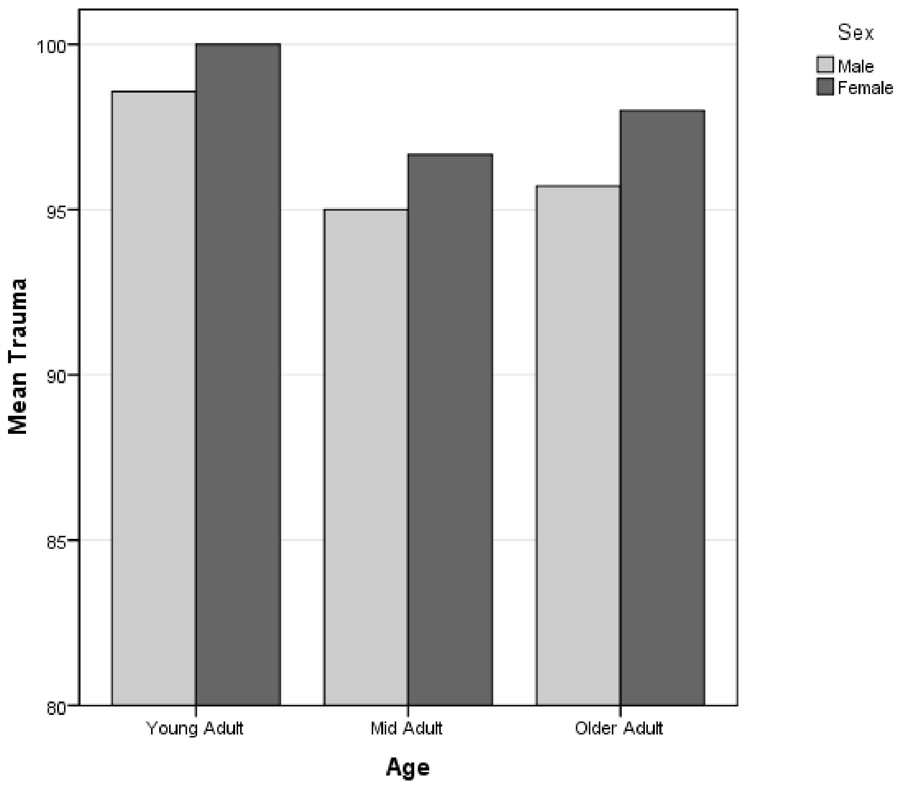

Figure 52: Mean trauma according to age and sex at Ban Non Wat and Noen U-Loke.

5.1.3 Long Bone Length

A control group containing long bone means was calculated using Bronze and Iron Age samples from archaeological sites in northeast Thailand (Table A 9 [p. 386]). The results obtained are based on the standard deviation of each individual in Ban Non Wat and Noen U-Loke away from that mean. As more sites are excavated that belong to the Bronze and Iron Age, these will be included in the calculation of the means and, in the future, Ban Non Wat and Noen U-Loke will also be included. In the interim, 26 individuals from Ban Non Wat and 30 from Noen U-Loke provided long bone lengths that could be analysed. The mean long bone lengths of Ban Non Wat and Noen U-Loke were very similar (Table 25), although, Ban Non Wat had an outlier (Figure 53). This individual had substantially shorter long bone lengths than other individuals from both sites as well as northeast Thailand samples. There were no significant differences between Ban Non Wat and Noen U-Loke ($t[54]=0.329$, $p>0.05$).

Older adults have higher scores in relation to long bone length scores (Figure 54). This suggests that taller individuals were more likely to survive into older age than shorter people. The shorter outlier seen at Ban Non Wat belongs to a young adult (Figure 55). There is no difference statistically between the three age groups as a one way ANOVA shows $F(2,53)=0.520$, $p>0.05$.

Table 25: Mean Long bone length score according to location.

	SITE	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Long bone length	Ban Non Wat	26	83.3642	15.30315	3.00120
	Noen U-Loke	30	82.0676	14.21594	2.59546

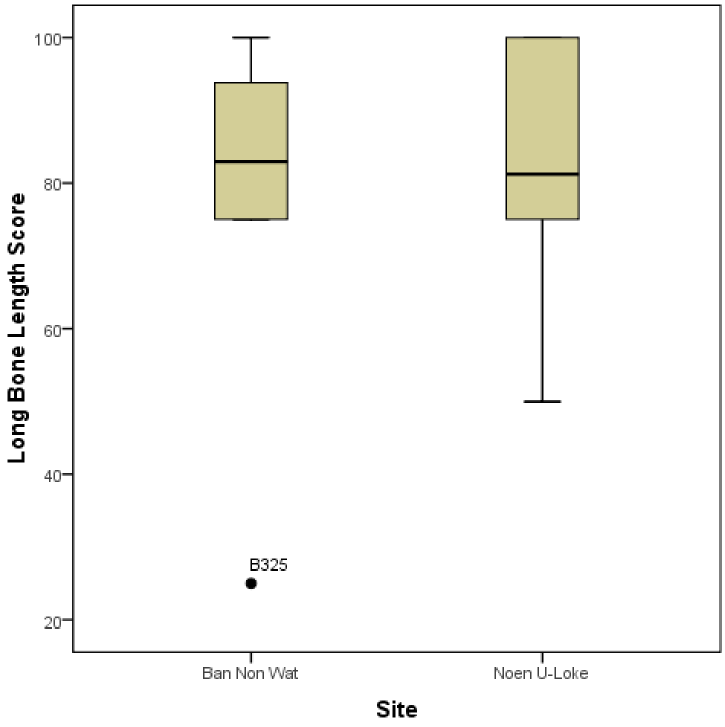

Figure 53: Boxplot of long bone lengths according to location.

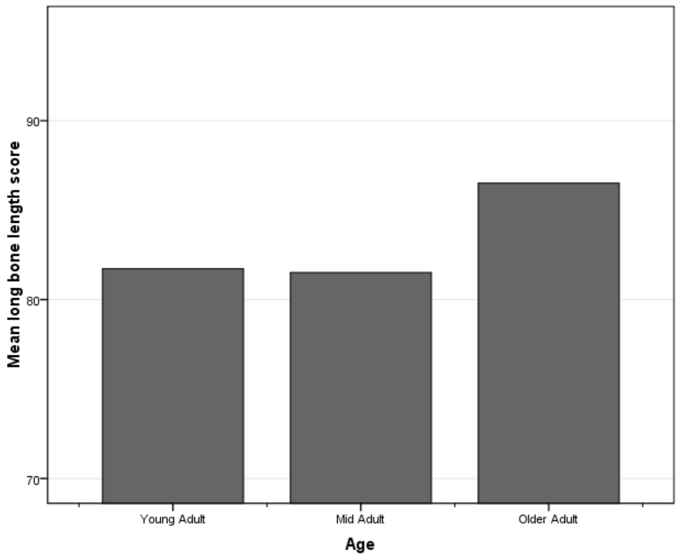

Figure 54: Mean long bone length score according to age groups at Noen U-Loke and Ban Non Wat.

When age is divided according to location, at Ban Non Wat young adults have the lowest long bone length mean score, whilst at Noen U-Loke, it is the mid adults that had the lowest mean (Figure 56). There are no statistically significant differences within each site between age groups: Ban Non Wat ($F[2,23]=0.834$, $p>0.05$) and Noen U-Loke ($F[2,27]=2.219$, $p>0.05$). There are no differences between young adults from Ban Non Wat and Noen U-Loke ($t[20]=-0.890$, $p>0.05$) or between older adults ($t[10]=-0.332$, but there is a statistical difference between the mid adults of Ban Non Wat and those of Noen U-Loke ($t[20]=2.320$, $p<0.05$). The mean scores as well as the boxplot (Figure 57) demonstrate that mid adults at Noen U-Loke are distinctly shorter than those at Ban Non Wat. The meaning of this difference is unclear, as the results for older and younger ages do not reflect this. If there was a height difference between Ban Non Wat and Noen U-Loke it would be expected that there would be a difference in long bone length means in all age groups.

The different age groups appear to have some similarities within each phase, except for the Mid Iron Age, where mid adults appear to be considerably lower in score than older and younger adults in the same phase (Figure 58). Examination of the boxplot shows that the Mid Iron Age sample of mid adults contains an outlier that may be skewing the result (Figure 59). There are no statistically significant differences between all young adults ($F[3,18]=0.267$, $p>0.05$), all mid adults ($F[3,18]=2.472$, $p>0.05$) or all older adults ($F[3,8]=0.066$, $p>0.05$) in the different phases. There are no statistically significant differences within each phase between the different age groups: Mid Bronze Age ($F[2,9]=0.142$, $p>0.05$), Late Bronze Age ($F[2,5]=0.097$, $p>0.05$), Early Iron Age ($F[2,18]=0.202$, $p>0.05$), and Mid Bronze Age ($F[2,12]=1.942$, $p>0.05$).

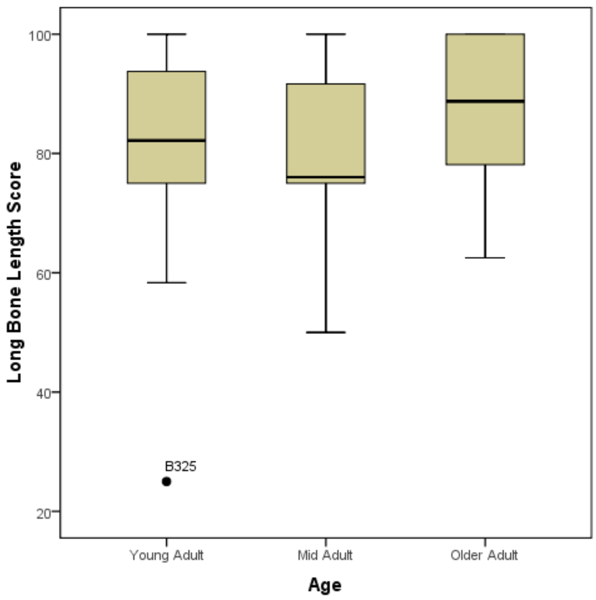

Figure 55: Boxplot of long bone lengths according to age at Noen U-Loke and Ban Non Wat.

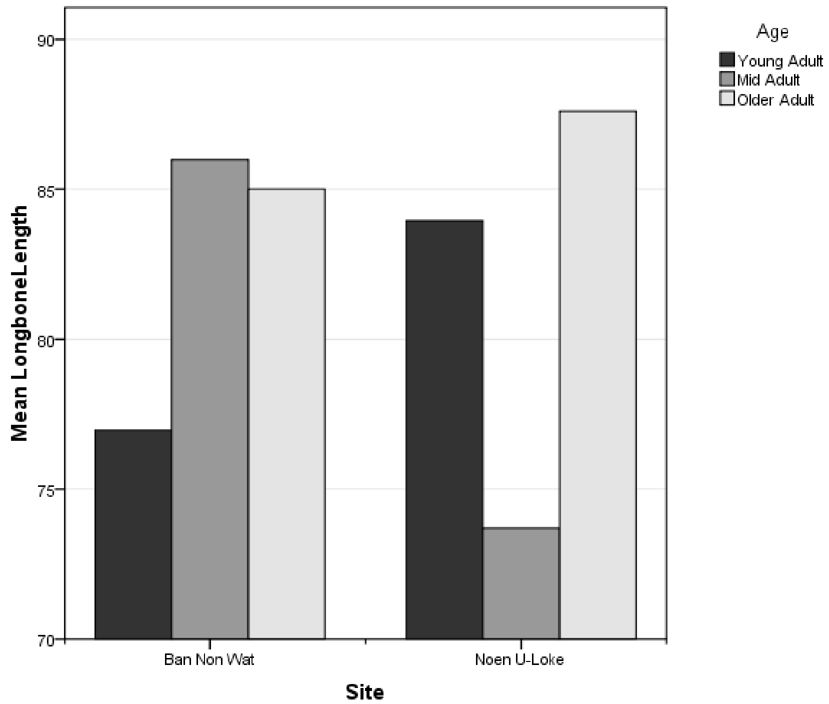

Figure 56: Mean long bone length according to site and age.

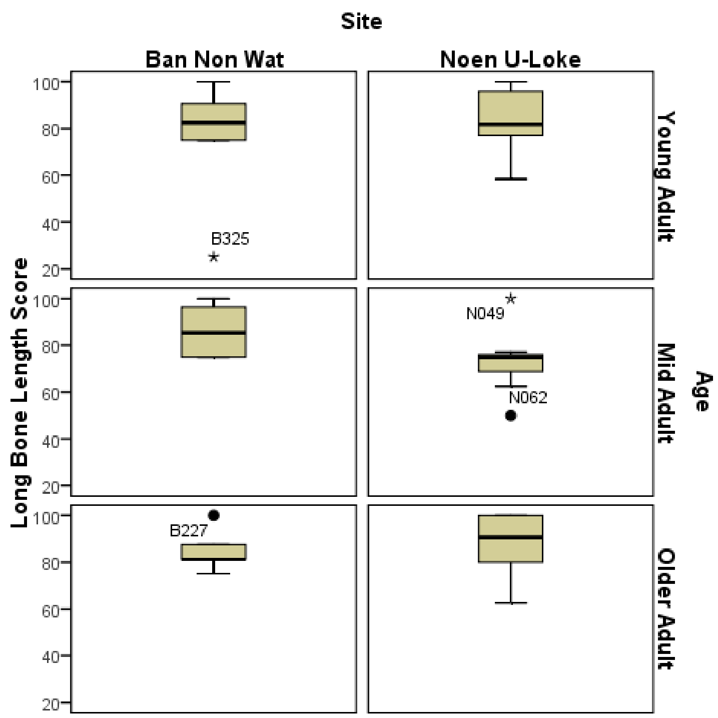

Figure 57: Boxplot of long bone length according to location and age.

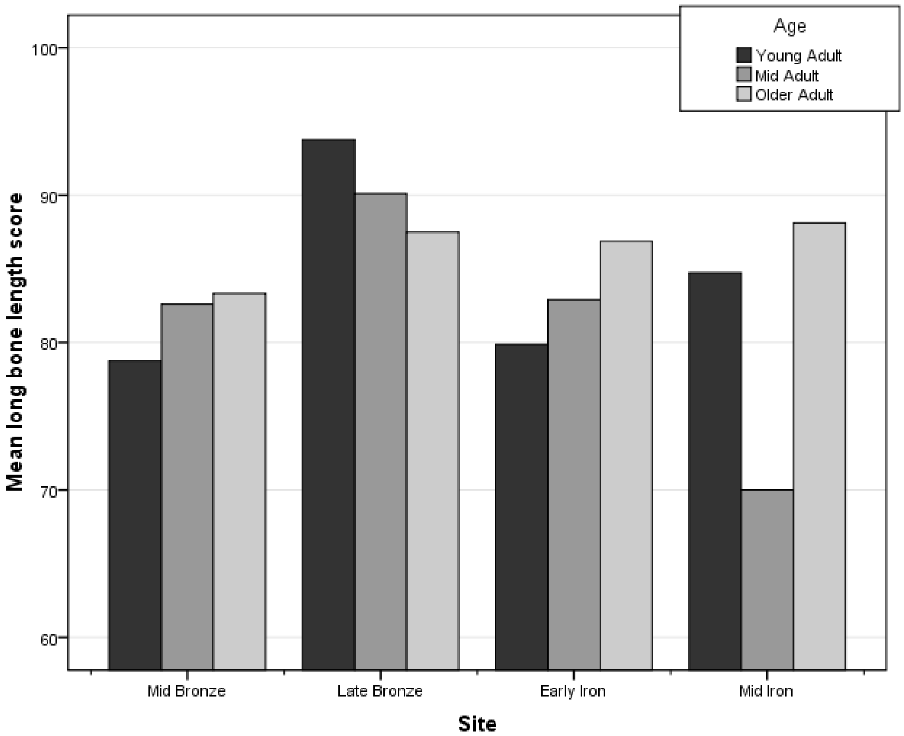

Figure 58: Long bone length mean according to age and phase.

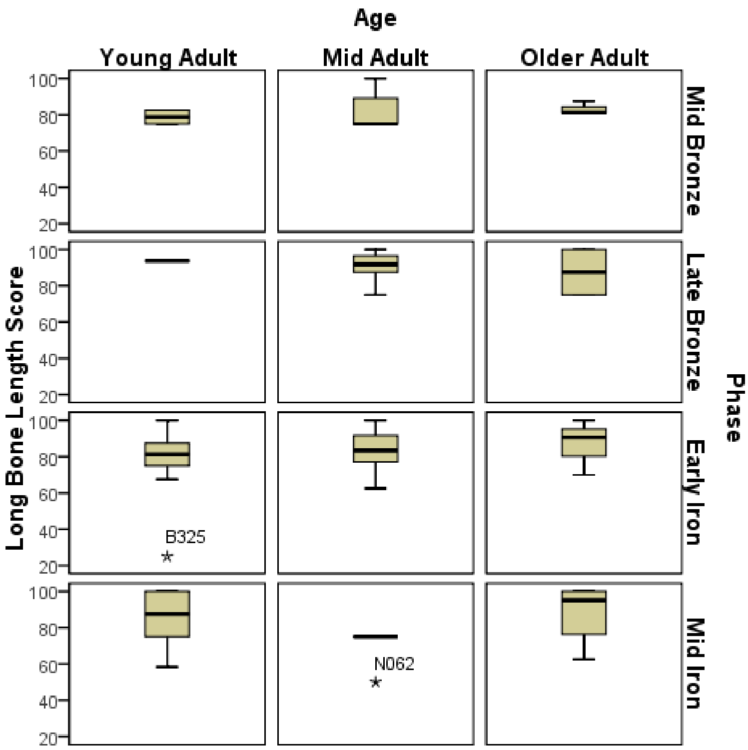

Figure 59: Boxplot of long bone length scores according to phase and age.

There is little difference between the mean long bone length scores for males and females (Table 26). The male sample has one outlier (Figure 60). There is no statistical significance between the sexes (t[53]=-0.225, p>0.05). In the site of Noen U-Loke, males have a higher mean long bone length score than females, but this relationship is reversed in Ban Non Wat (Figure 61). The differences between males and females in each site are not statistically significant: Ban Non Wat (t[23]= -0.446, p>0.05) and Noen U-Loke (t[28]= 0.140, p>0.05. There are also no significant differences between females in Ban Non Wat and Noen U-Loke (t[21]=0.474,p>0.05), or between the male samples (t[30]=-0.1458, p>0.05).

Table 26: Descriptive statistics of long bone length within the sexes at Ban Non Wat and Noen U-Loke.

SEX	MEAN	N	STD. DEVIATION	STD. ERROR OF MEAN
Male	81.9774	32	15.69310	2.77417
Female	82.8791	23	13.12114	2.73595
Total	82.3545	55	14.55066	1.96201

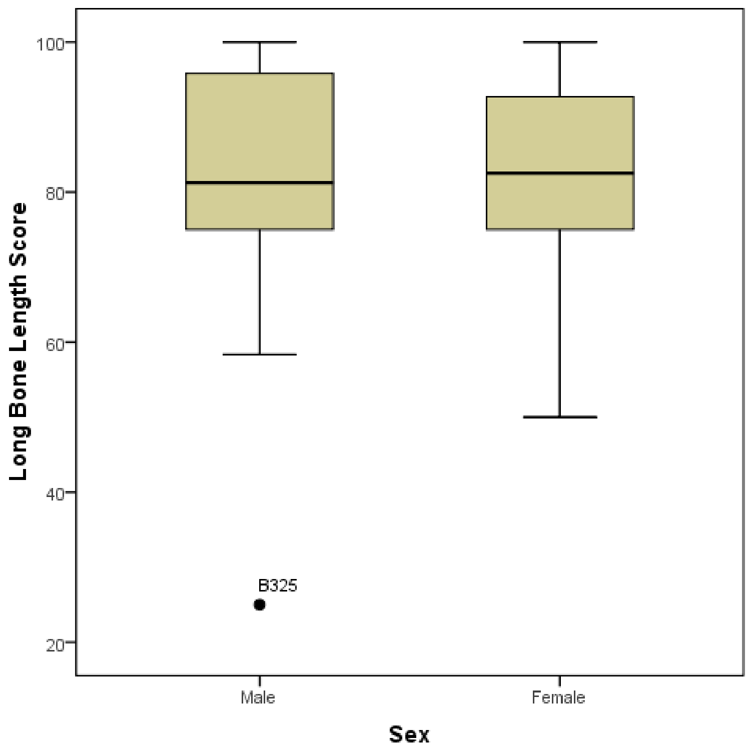

Figure 60: Boxplot of long bone length of sample of Ban Non Wat and Noen U-Loke according to sex.

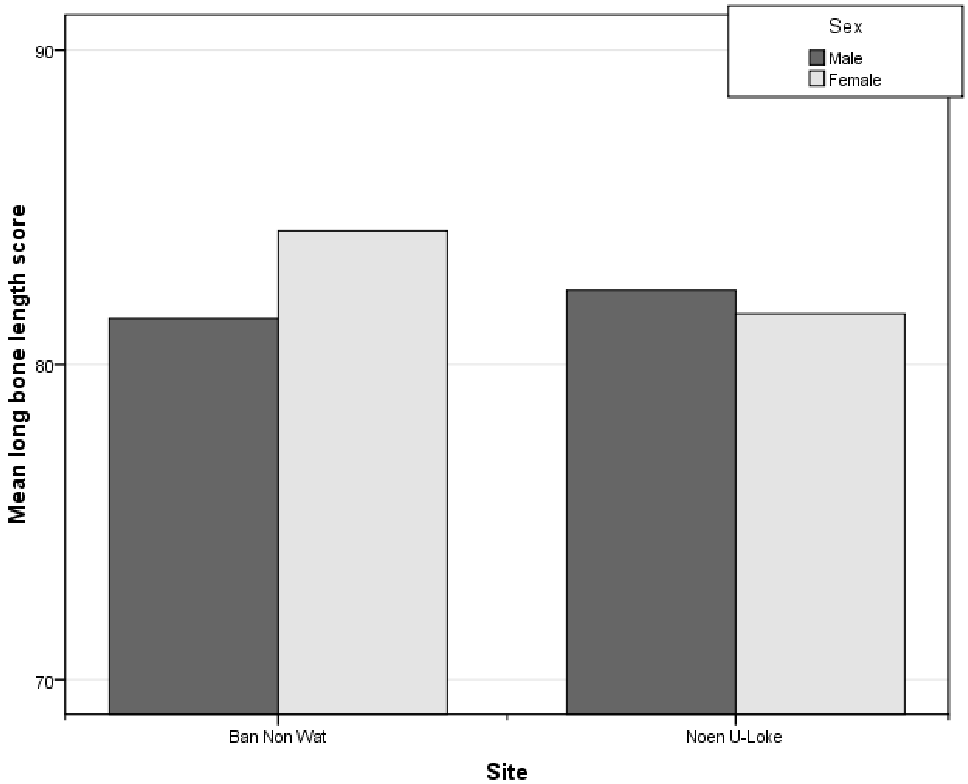

Figure 61: Mean long bone length score according to site and sex.

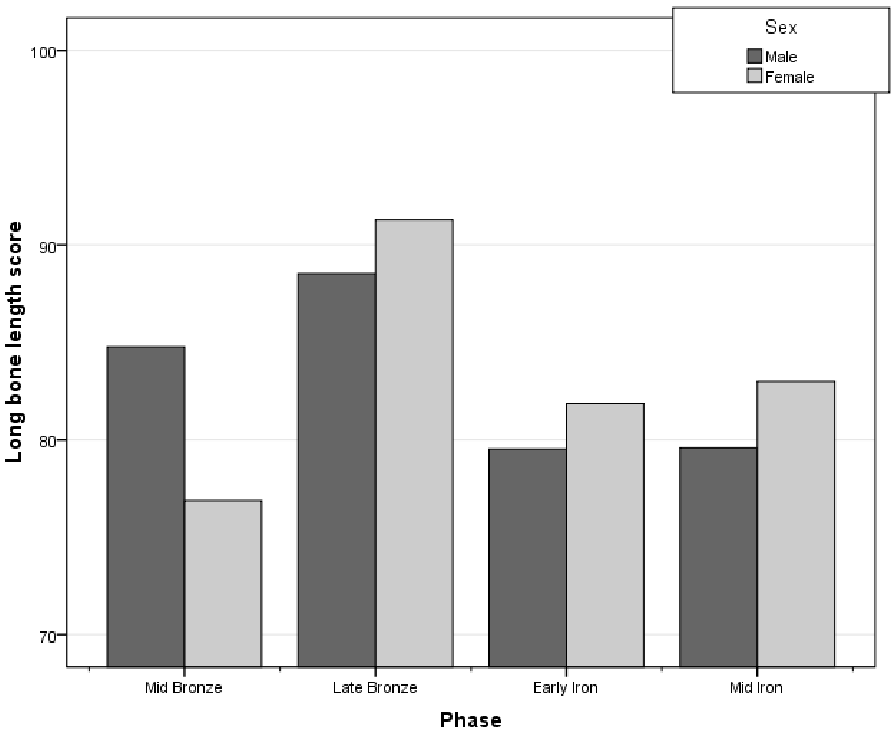

Figure 62: Long bone length mean according to sex and phase.

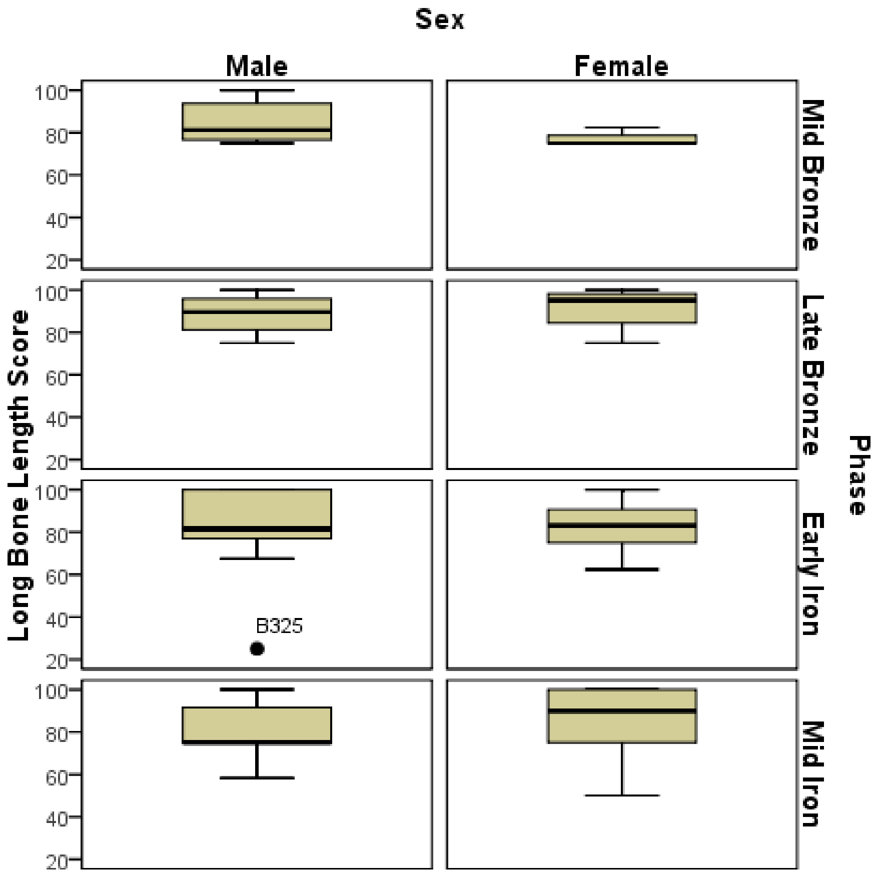

Figure 63: Boxplot of long bone length scores according to phase and sex.

Male and female mean long bone lengths are similar in all phases except for the Mid Bronze Age (Figure 62). The difference between males and females in the Mid Bronze Age is statistically significant (t[10]=1.564, p>0.05),which can also be seen in Figure 63. There is no statistical difference amongst the males in the different phases (F[3,28]=0.452, p>0.05) or between the females (F[3,19]=0.828, p>0.05).

When the sexes are separated into sites, males from Ban Non Wat in the Early Iron Age have distinctly lower scores than other males, but there is little difference amongst the males (Figure 64). Isolating Ban Non Wat, there is no statistical difference amongst the males in the three phases (χ^2[2,N=14]=1.671, p>0.05) or between the females (F[2,8]=2.943, p>0.05). Within Noen U-Loke there is no difference in the male sample between the Early and Mid Iron Age (t[16]-=0.979, p>0.05), or the female sample (t[10]=-0.245, p>0.05). There is no statistical difference between the males from both sites in the Early Iron Age (□^{2} [7,n=10]=10.00, p>0.05).

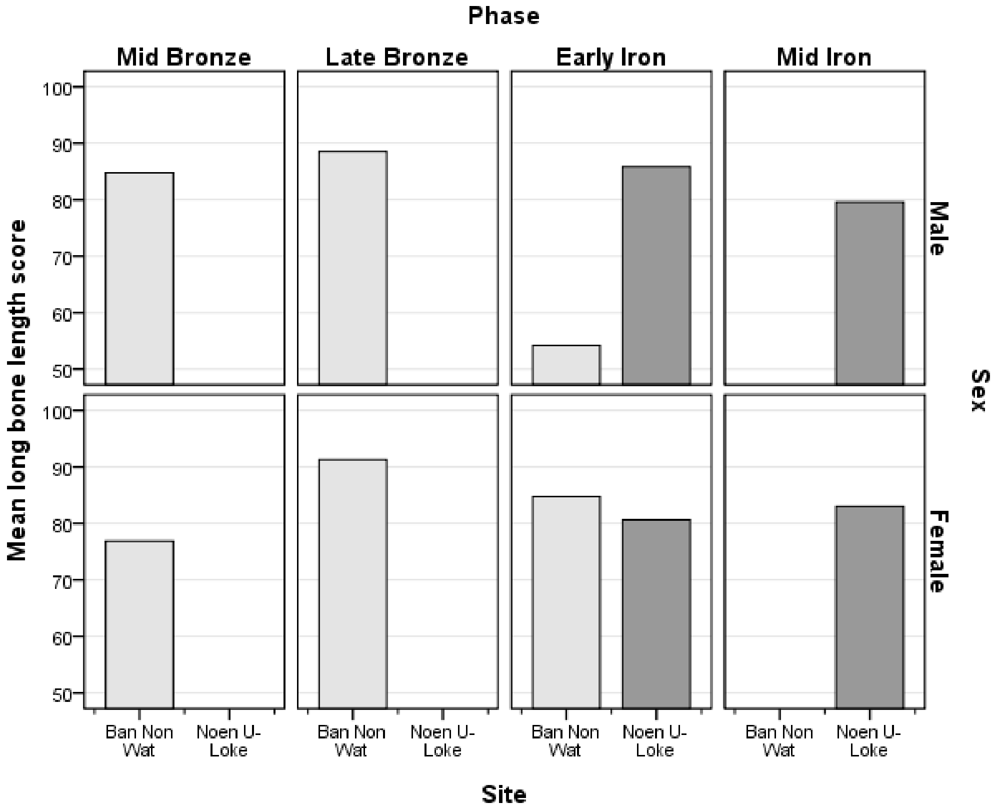

Figure 64: Mean long bone score according to sex, location and phase.

The Late Bronze Age sample contains the highest long bone length score (Figure 65), although the boxplot shows little difference between the phases (Figure 66). There is no statistical significance between the phases ($F[3,52]=0.778$, $p>0.05$).

Comparing the two sites in the Early Iron Age, Ban Non Wat appears to be much lower in long bone score than Noen U-Loke (Figure 67), although this difference is not significant ($t[19]= -0.752$, $p>0.05$).

Older adult females have a better long bone length score on average (Figure 68), however this is not statistically significant in any age group: young adult ($t[19]= -0.699$, $p>0.05$), mid adult ($t[20]= 1.099$, $p>0.05$) and older adult ($t[10]= -0.816$, $p>0.05$). There is also no statistically significant difference amongst males in the different age ranges ($F[2,29]=0.431$, $p>0.05$) or in the females of different ages ($F[2,20)=1.520$, $p>0.05$).

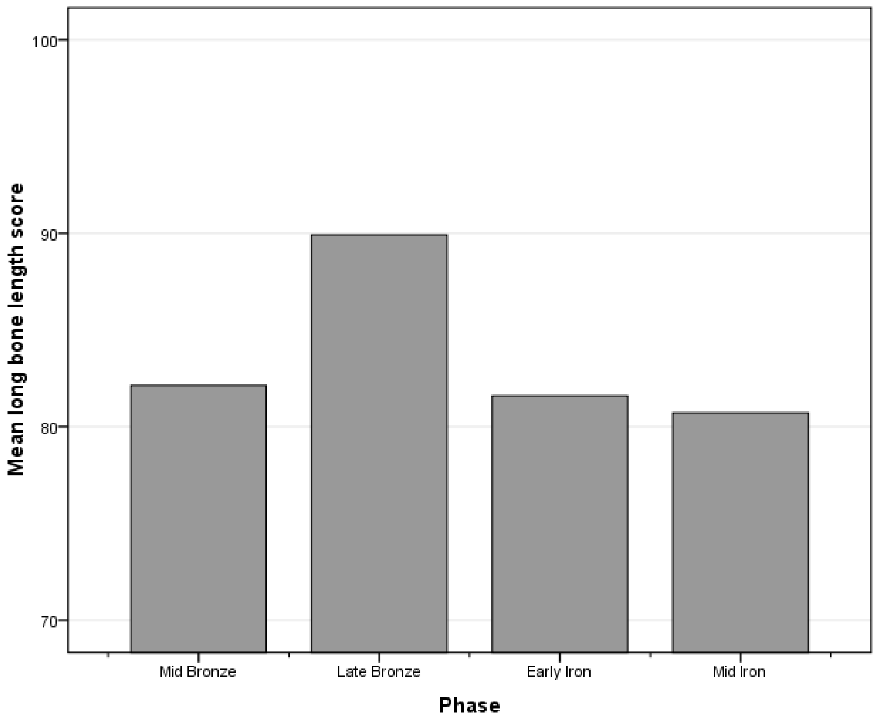

Figure 65: Mean long bone length score according to phase.

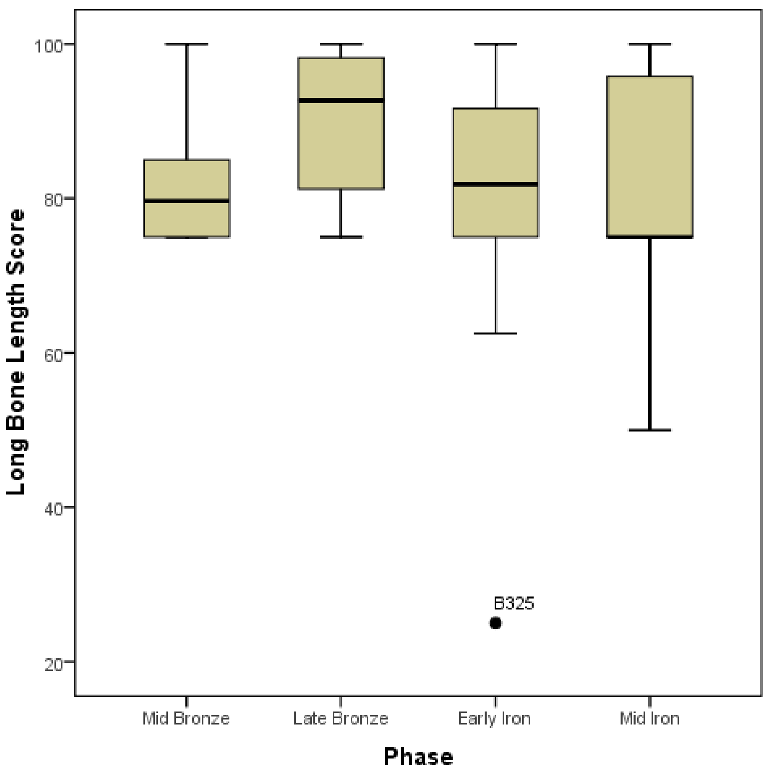

Figure 66: Boxplot of long bone lengths according to phases.

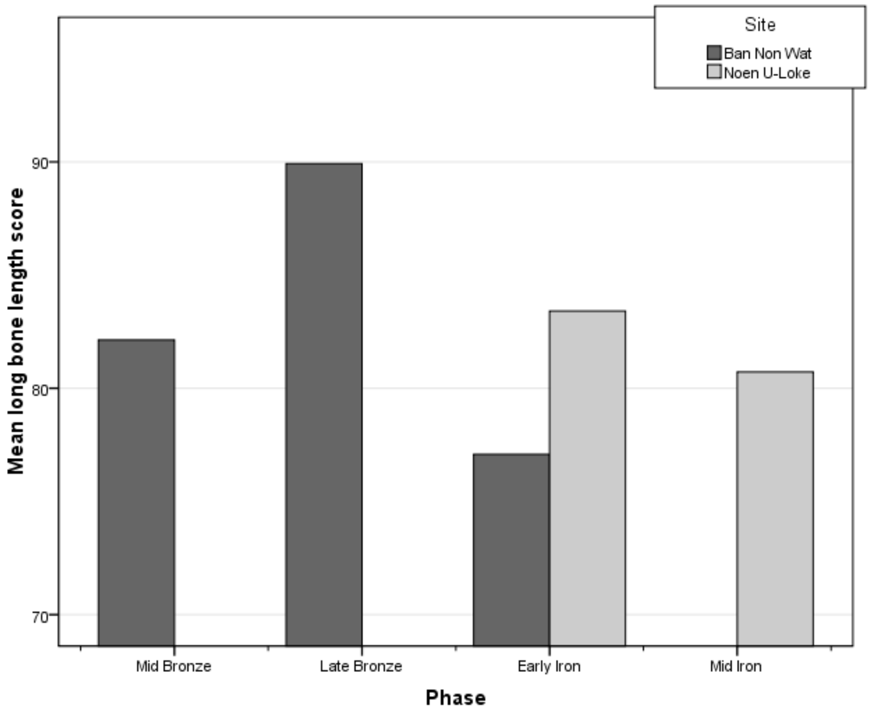

Figure 67: Mean long bone length according to site and phase.

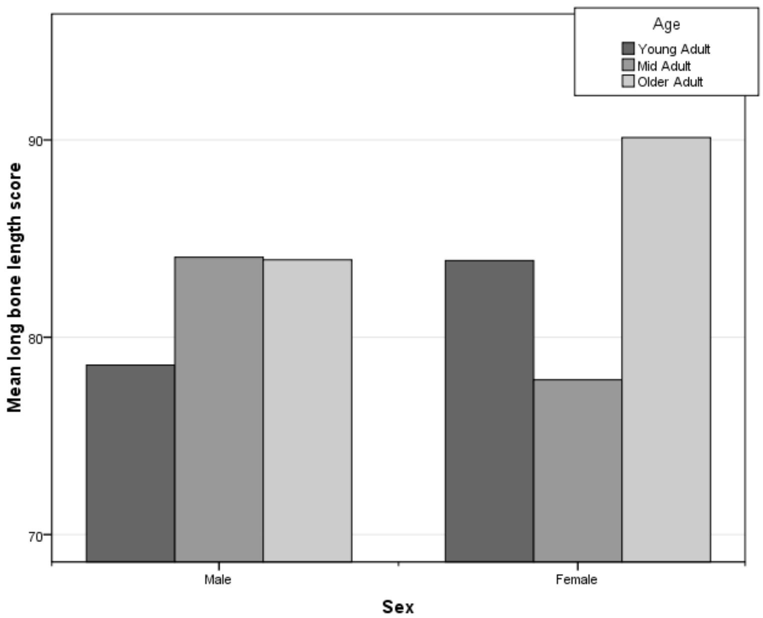

Figure 68: Long bone length according to sex and age.

Figure 69 displays the mean long bone lengths by age, sex and phase. There is no statistical difference between young adult males (F[1,10]=0.165, p>0.05), mid adult males (χ^2[3,N=13]=5.798, p>0.05) or older males (χ^2[3,N=7]=2.306, p>0.05) due to phase. There is also no statistical difference between young adult females (χ^2[2,N=5]=1.842, p>0.05), mid adult females (F[3,5]=0.952, p>0.05) or older females (F[3,5]=4.837, p>0.05) due to phase.

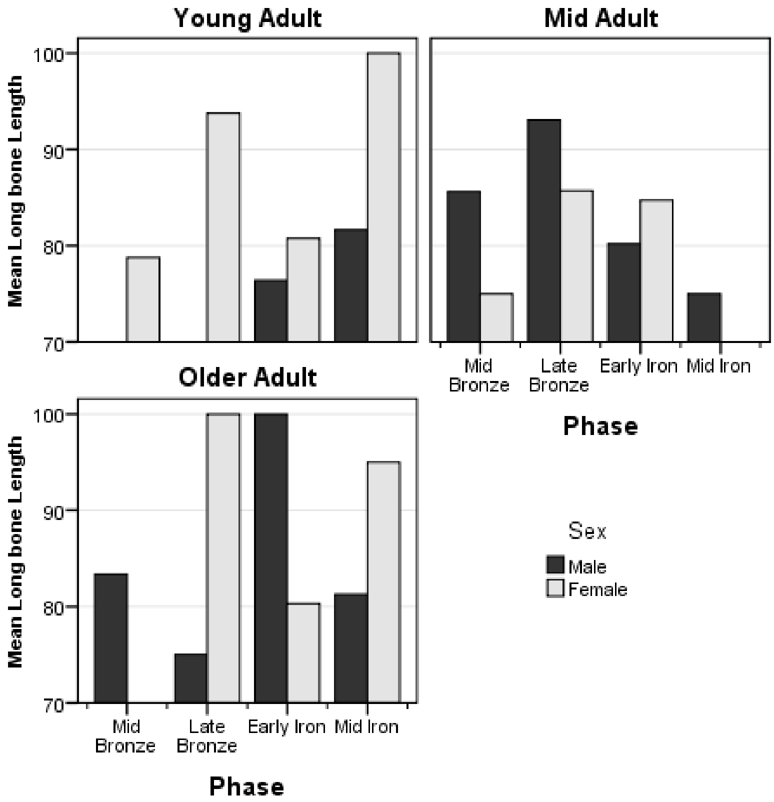

Figure 69: Mean long bone length according to sex, age and phase.

5.1.4 Enamel Hypoplasia

Enamel hypoplasias are indicative of juvenile growth disruptions. Overall, Ban Non Wat had less growth interruptions than Noen U-Loke according to the mean EH score (Table 27). A boxplot of scores from both sites (Figure 70) shows that there is a difference between the two sites. At Ban Non Wat, the majority of the sample has no EH and there are six outliers. Noen U-Loke has a range that covers all scores, but over half (63%) of the sample had no evidence of EH. The difference between the two sites is not statistically significant (χ^2 [2,N=81] =2.526, $p>0.05$).

Table 27: Mean EH score according to location.

SITE	MEAN	N	STD. DEVIATION
Ban Non Wat	84.21	38	33.095
Noen U-Loke	72.09	43	39.795
Total	77.78	81	37.081

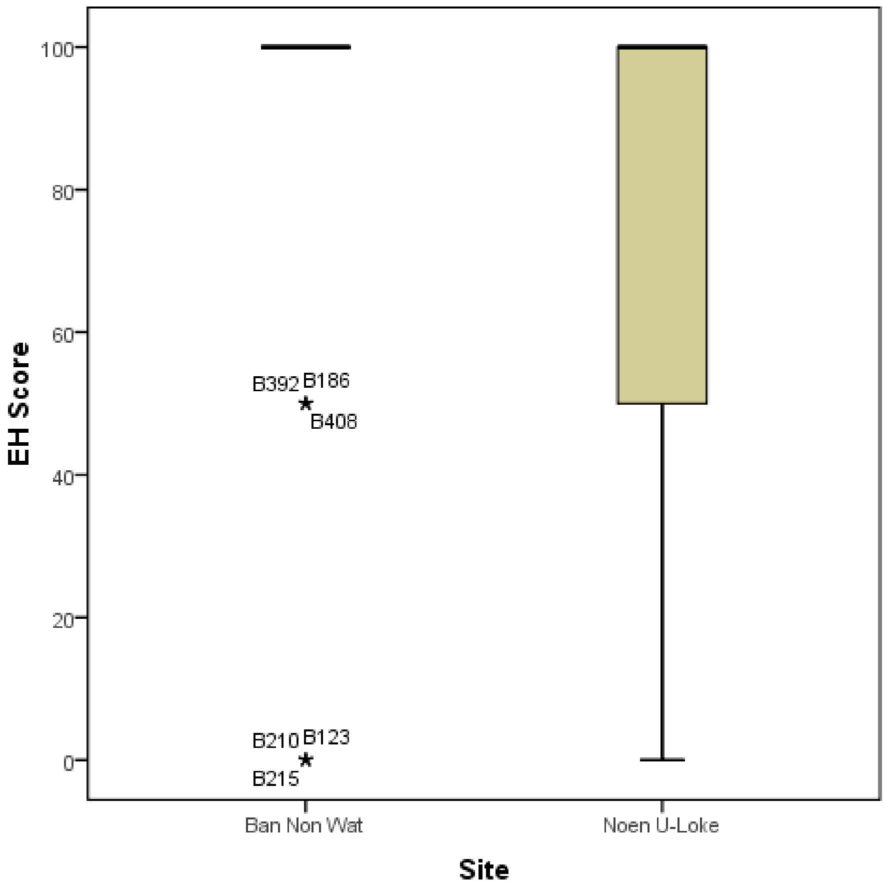

Figure 70: Boxplot of EH score according to location.

Based on mean enamel hypoplasia score, young adults have a higher prevalence of growth disturbance (Figure 71). This suggests that the young adults suffered conditions during their juvenile years that may have influenced their adult health, and as a result could not survive into mid adult age. The range of EH scores according to age shows that a mid adult score below 100 or 'no EH' is an anomaly (Figure 72). However, there is no statistical difference between the age groups (χ^2[2,N=81]=1.768, $p>0.05$).

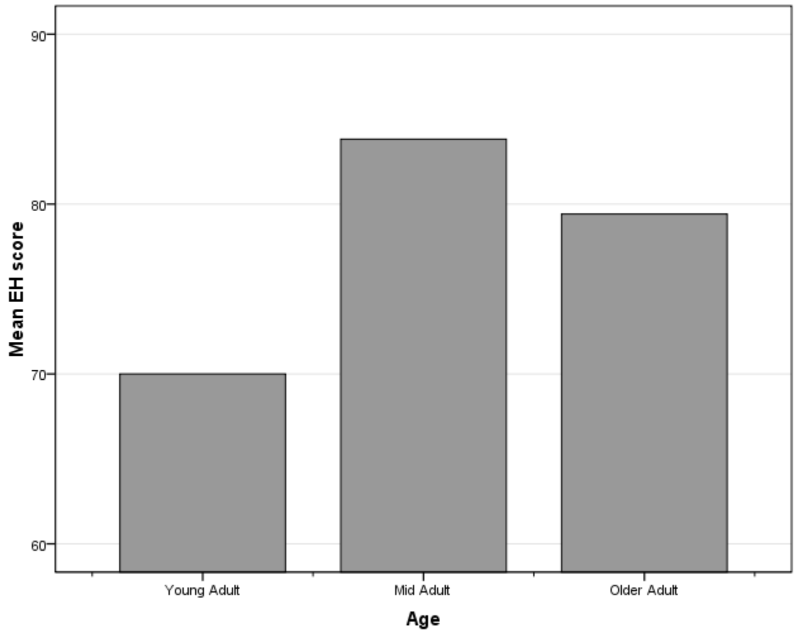

Figure 71: Mean EH score according to age at Ban Non Wat and Noen U-Loke.

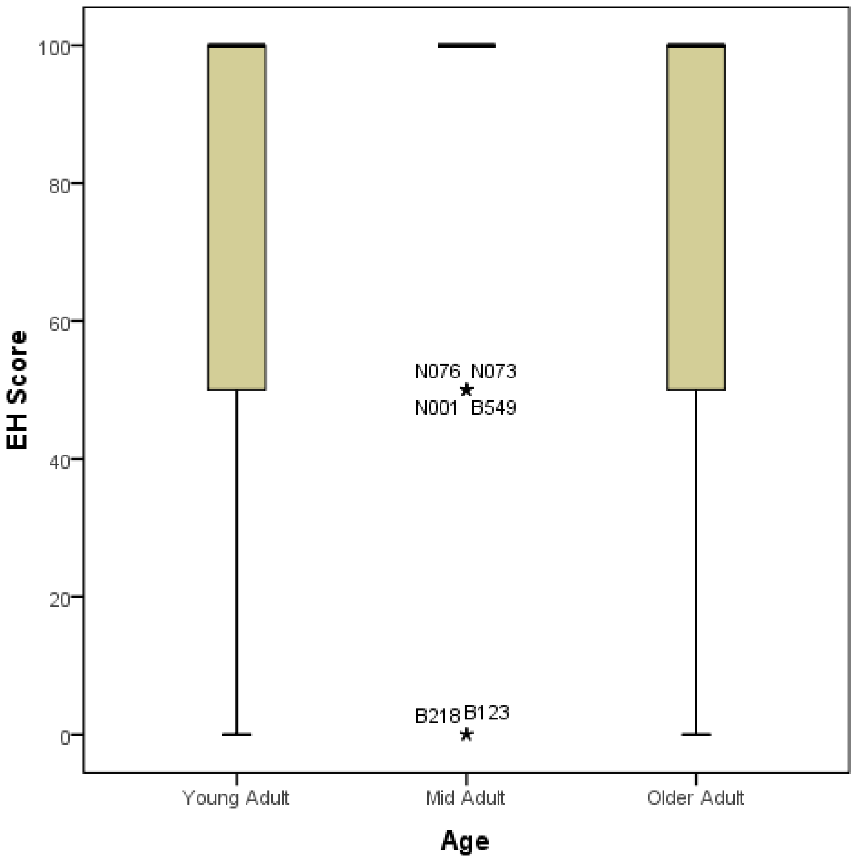

Figure 72: Boxplot of EH scores according to age.

The pattern of mean EH score according to age appears different for the two sites (Figure 73). In Ban Non Wat, young adults have few growth disruptions, however mid and older adults have survived juvenile growth disruptions. At Noen U-Loke, younger adults had considerably more growth disruptions. Those that survived into mid and older adult age appeared to have had lesser growth disruptions in childhood. It suggests that in Ban Non Wat, juveniles with growth disruptions were looked after by their health system, whereas in Noen U-Loke it meant you were unlikely to survive beyond 30 years of age. There is a statistically significant difference between young adults in Ban Non Wat and those at Noen U-Loke (χ^2 [2,N=30] =7.444, $p<0.05$). This can also be seen in the Figure 74. Individuals who died as young adults in Noen U-Loke statistically are more likely statistically to have had a growth disruption during childhood. There are no statistical differences between mid adults of Noen U-Loke and Ban Non Wat (t[32]= -0.661, $p>0.05$) or older adults (t[15]= -0.470, $p>0.05$). In addition there is no statistically significant differences between the age groups of Ban Non Wat (χ^2[2,N=38]=3.492, $p>0.05$) or those at Noen U-Loke (χ^2[2,N=43]=5.195, $p>0.05$).

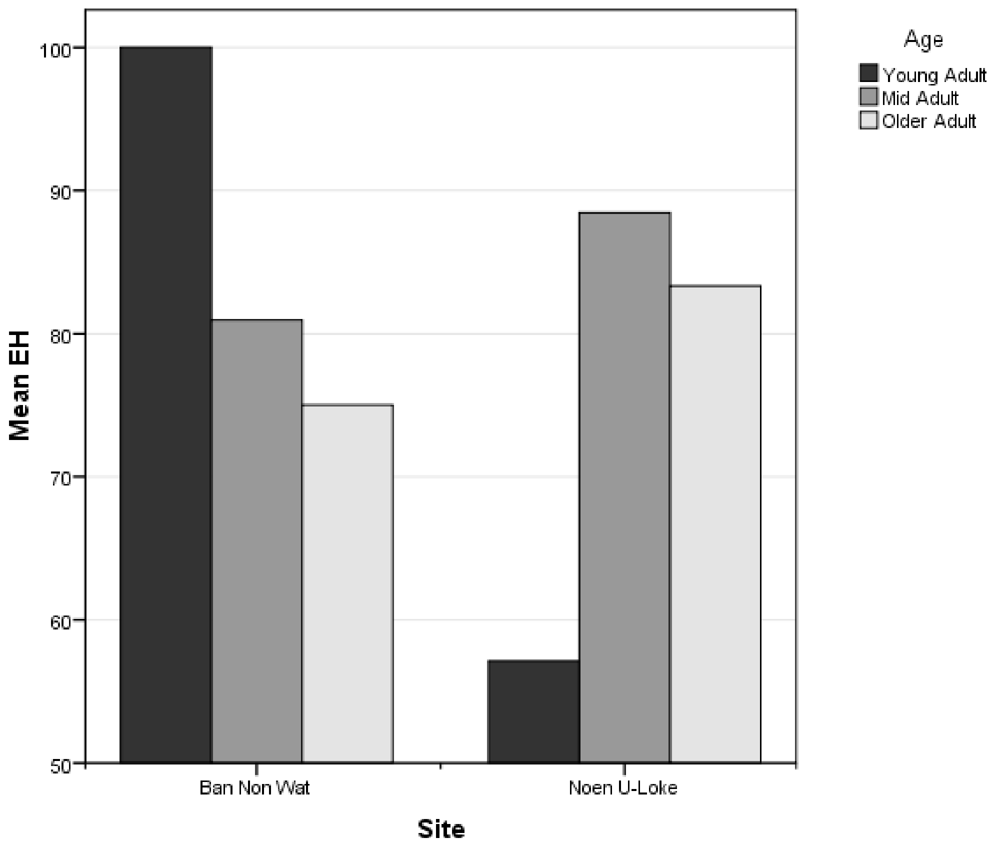

Figure 73: Mean EH Score according to location and age.

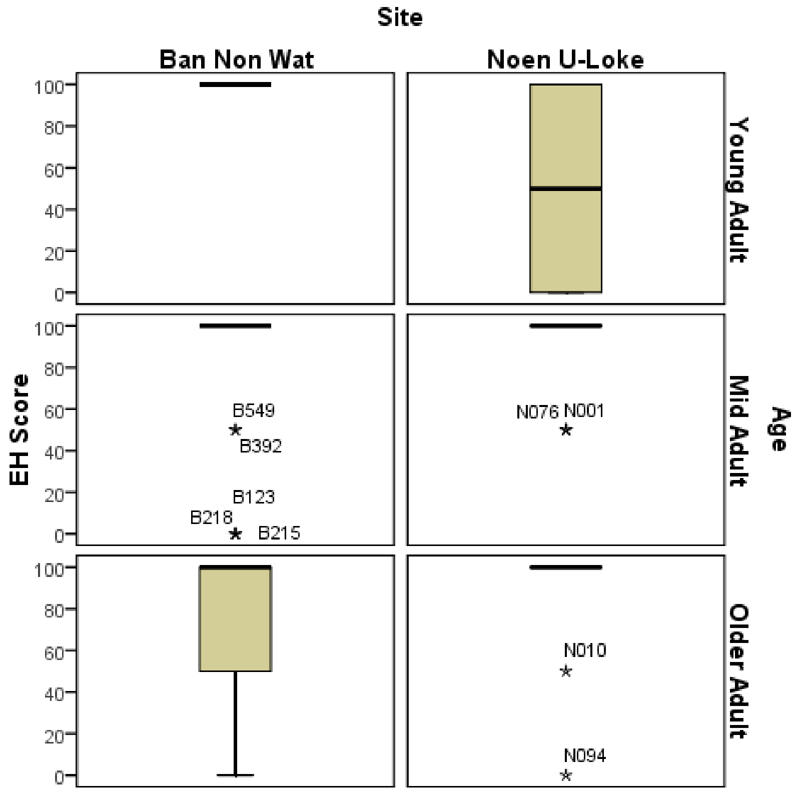

Figure 74: Boxplot of EH score according to age and location.

Separating the age groups into phases, the Bronze Age is markedly different to the Iron Age in relation to young adults (Figure 75 and Figure 76), although this appears to be the product of sample size as there are only three young adults in the Bronze Age sample. There are no statistical differences between the age groups in the Mid Bronze Age ($\chi^2[2,\underline{N}=13]=1.757$, $p>0.05$), the Late Bronze Age ($\chi^2[2,\underline{N}=9]=1.000$, $p>0.05$) or the Mid Iron Age ($\chi^2[2,\underline{N}=24]=0.505$, $p>0.05$). However, there are statistical differences between age groups in the Early Iron Age ($\chi^2[2,\underline{N}=32]=8.059$, $p<0.05$). This suggest that people in the Early Iron Age were unlikely to survive over 30 if they suffered a growth disruption during their childhood. There are no statistical differences between young adults in each of the four phases ($\chi^2[3,\underline{N}=30]=1.840$, $p>0.05$), as well as between the mid adults ($\chi^2[3,\underline{N}=34]=6.972$, $p>0.05$) and older adults ($\chi^2[3,\underline{N}=17]=3.638$, $p>0.05$). There is no statistically significant difference between mid adults of the Mid Bronze and Late Bronze Ages (χ^2 [2,N=13] =5.455, $p>0.05$). There is a significant statistical difference between mid adults from the Late Bronze to the Early Iron Age ($t[15]=-3.115$, $p<0.05$). Mid adults in the Early Iron Age sample did not have growth disruptions that produced EH, but survival in the Late Bronze Age from juvenile growth disruptions had little effect on adults.

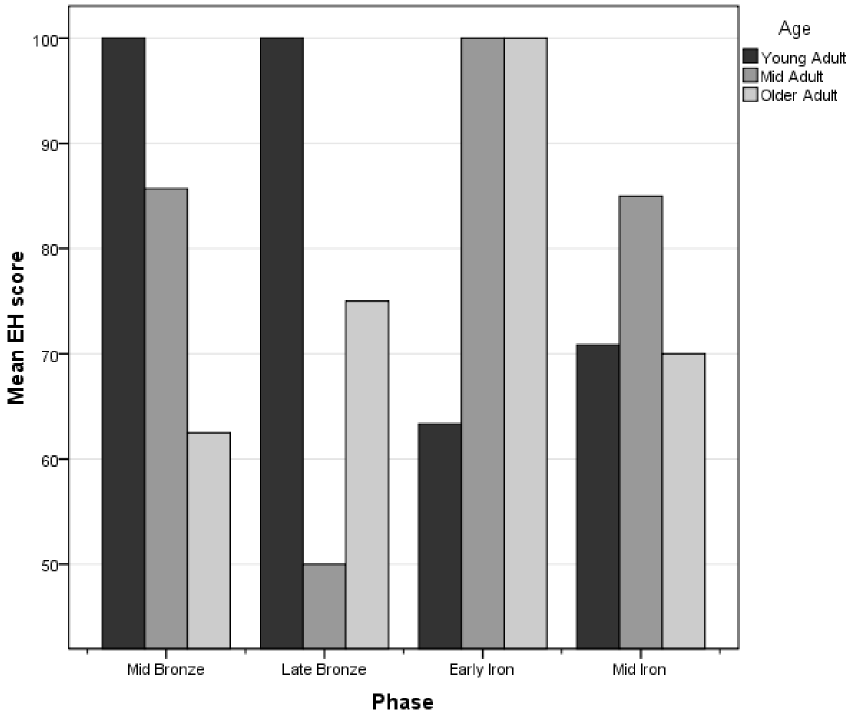

Figure 75: Mean EH score according to phase and age.

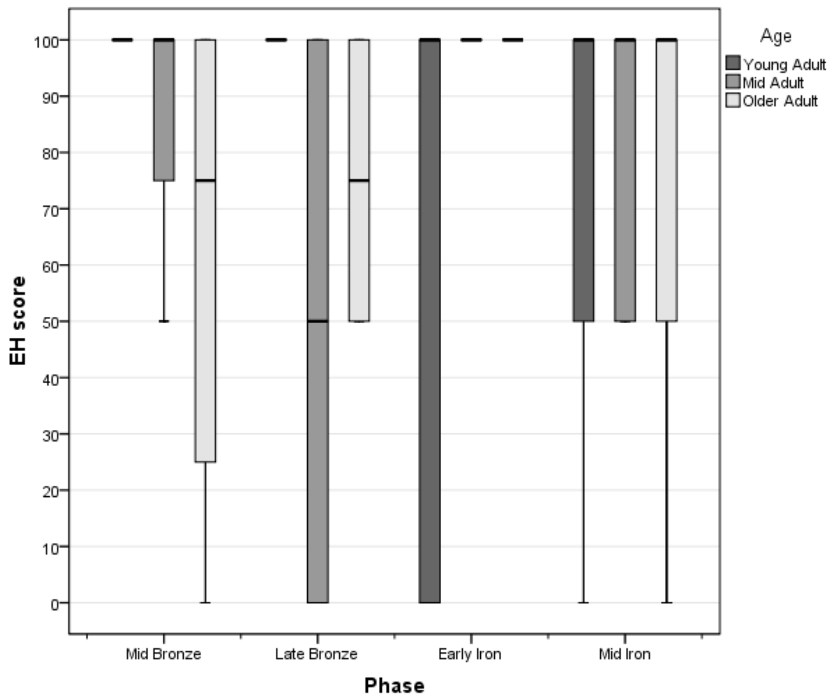

Figure 76: Boxplot of EH score according to age and phase.

Males had a lower EH score on average than females (Table 28). This difference is not statistically significant (t[66]=-1.126, p>0.05). The same pattern is apparent in each site (Figure 77), but there appears to be a difference at Ban Non Wat between males and females (Figure 78). However, there are no statistically significant differences between the sexes within each site: Ban Non Wat (t[31]= -1.090, p>0.05) and Noen U-Loke (t[33]= -0.470, p>0.05). There are also no statistical differences between females of Ban Non Wat and Noen U-Loke (t[33]=0.496, p>0.05) as well as between the males from the two sites (t[31]=1.024, p>0.05).

Table 28: Mean EH according to sex at Noen U-Loke and Ban Non Wat.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
EH	Male	35	71.43	38.892	6.574
	Female	33	81.82	37.119	6.462

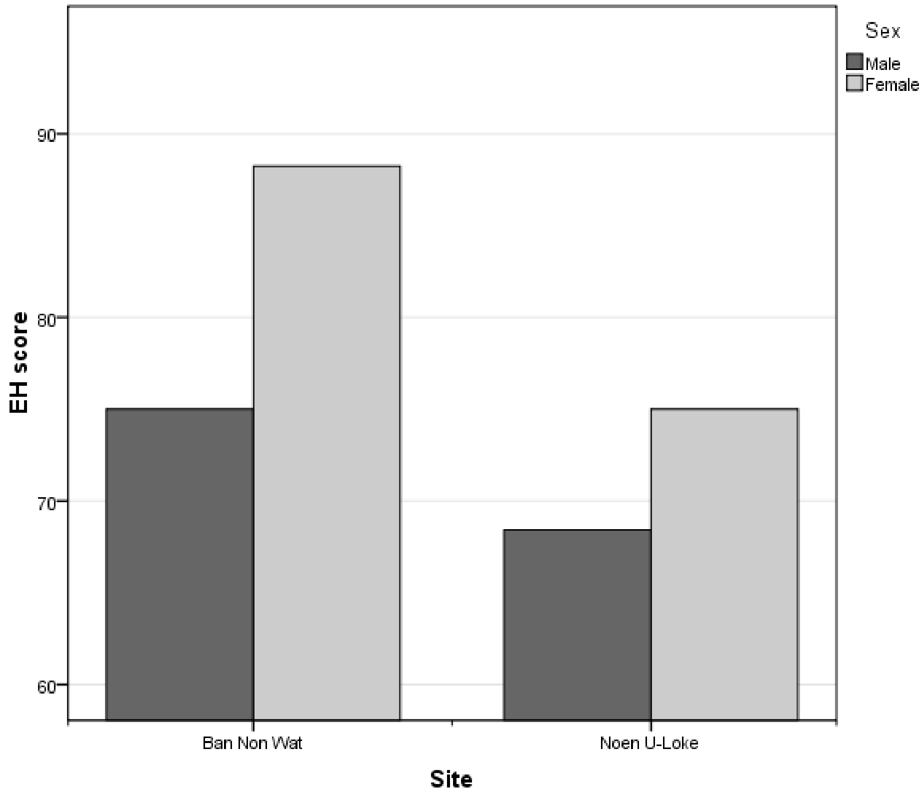

Figure 77: Mean EH score according to sex and location.

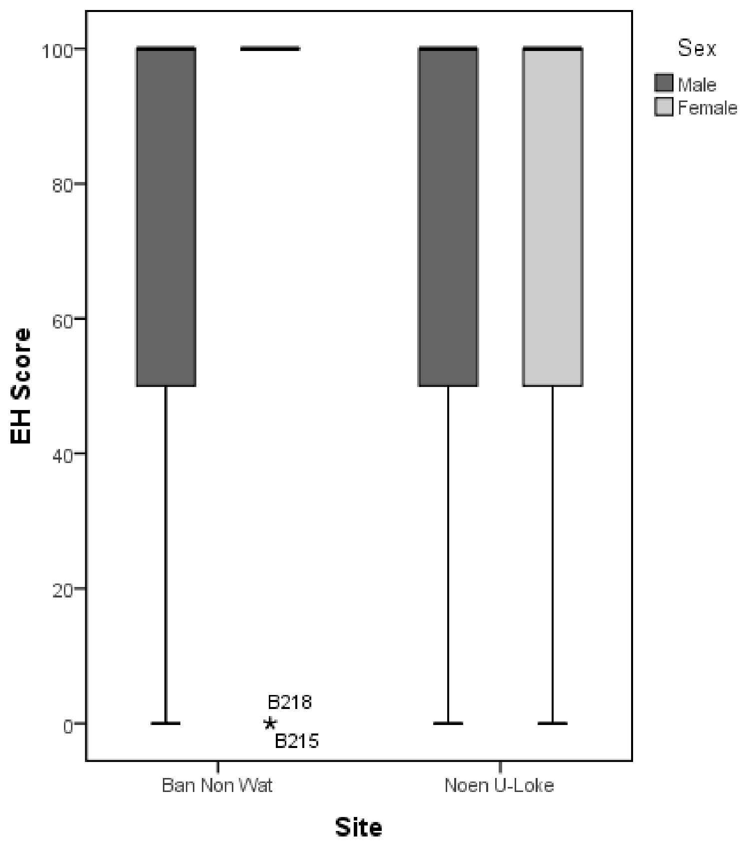

Figure 78: Boxplot of EH scores according to sex and location.

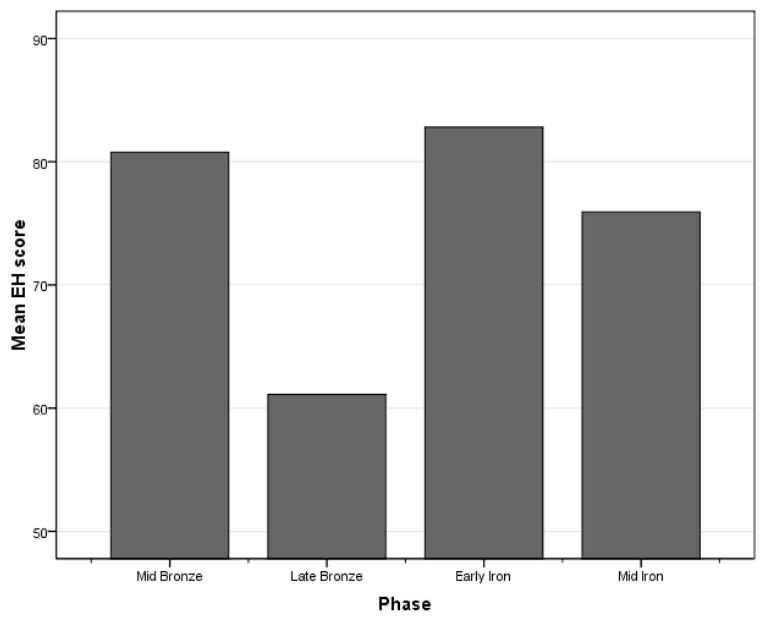

Figure 79: Mean EH score according to phase.

Following the examination of mean EH scores within the phases, it appears that the Late Bronze Age had relatively more growth disturbances in childhood (Figure 79), although the boxplot in Figure 80 shows the Early Iron Age as being distinctive. Despite this, there are no statistical differences between the phases (F[3,77]=0.849, p>0.05).

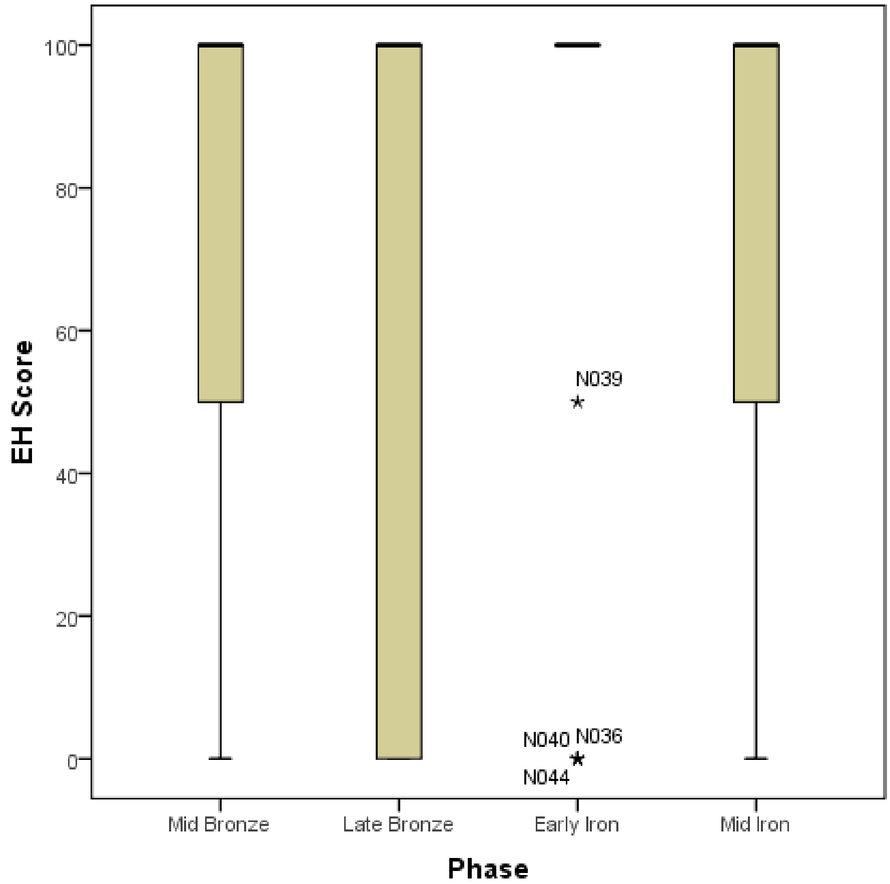

Figure 80: Boxplot of EH score according to phase.

When the sites are calculated separately based on phase, it appears that at Noen U-Loke, EH score improves over time (Figure 81). There is no statistical difference between the Early Iron Age and Mid Iron Age at Noen U-Loke (χ^2 [2,N=43] =4.281, p>0.05). Ban Non Wat also shows an increase in time, but the Late Bronze Age sees a dramatic drop in score and this difference is statistically significant (χ^2[2,N=34]=6.972, p>0.05). The phase that contains both a sample from Ban Non Wat and Noen U-Loke is the Early Iron Age (Figure 81 and Figure 82). Ban Non Wat has a distinctly superior EH score than Noen U-Loke. This difference is statistically significant (χ^2 [2,N=32] =7.385, p<0.05).

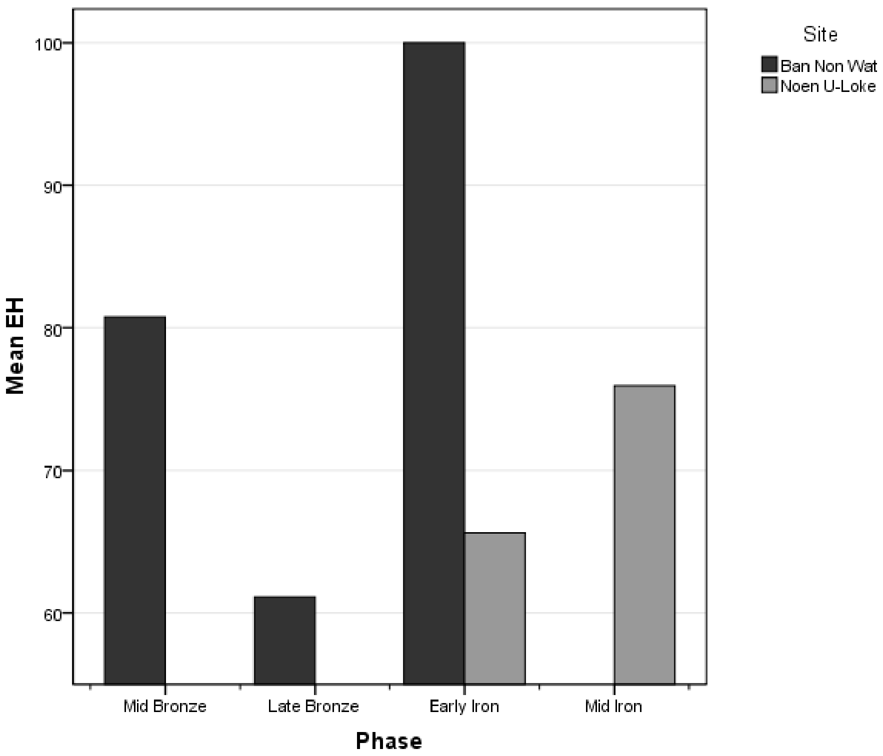

Figure 81: Mean EH score according to site and phase.

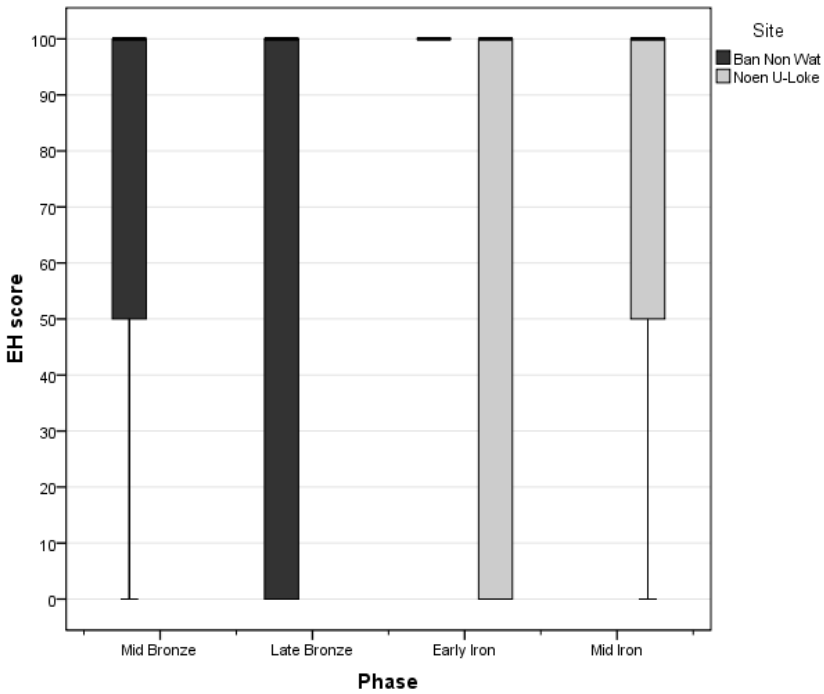

Figure 82: Boxplot of EH Scores according to phase and location.

When the sexes are plotted against phases, it appears that females in the Mid Bronze Age and Early Iron Age have less growth disruptions during childhood than males in the same phase (Figure 83). Whilst there is a decline in score from the Mid to Late Bronze Age for males, the decline for females is more distinct. Despite the differences between the samples in each of the phases (Figure 84), there is no statistical significance amongst the females represented in the four phases ($F[3,31]=0.154$, $p>0.05$) or amongst the males ($\chi 2[3,N=33]=5.00$, $p>0.05$) or between males and females in each phase: Mid Bronze Age (χ^2 [2,N=13] =0.164, $p>0.05$), Late Bronze($t[6]=0.333$, $p>0.05$), Early Iron Age ($t[26]=-1.116$, $p>0.05$) and Mid Iron Age ($t[17]=0.137$, $p>0.05$).

Comparing age and sex with mean EH score, it is apparent that although there is a pattern for both sexes that the younger an individual died, the higher likelihood that a childhood growth disruption occurred (Figure 85), there is an inconsistency in older males. This suggests that males have a better chance of survival even if they have suffered childhood growth disruptions than females. The boxplot showing age and sex shows a large difference between mid adult males and females (Figure 86). There is no statistical difference between the males in different age groups ($F[3,32]=1.067$, $p>0.05$) or between the females ($\chi^2[2,\underline{N}=33]=2.517$, $p>0.05$). In addition there is no significant difference males and females in the young adult group ($t[23]=-0.018$, $p>0.05$), mid adult group ($t[24]= -1.086$, $p>0.05$) or the older adult age group (χ^2 [2,N=17] =4.958, $p>0.05$).

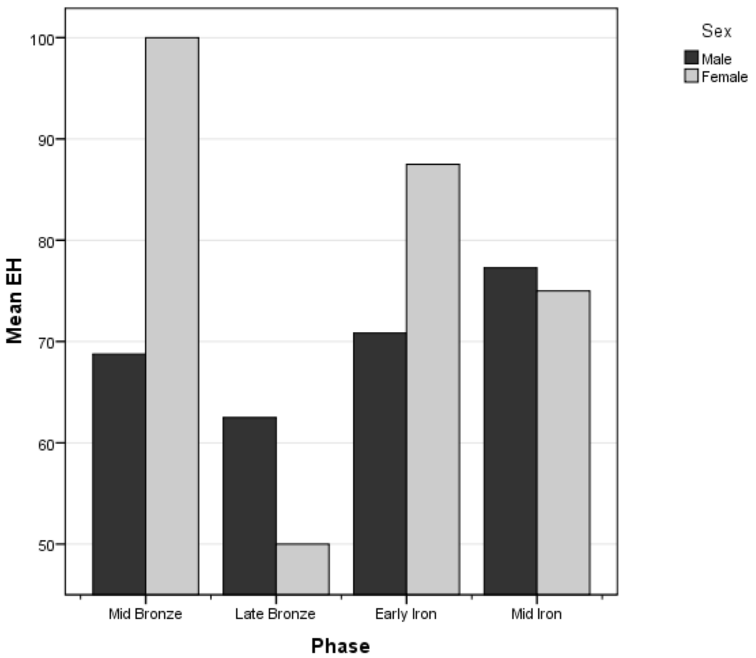

Figure 83: Mean EH Scores according to sex and phase.

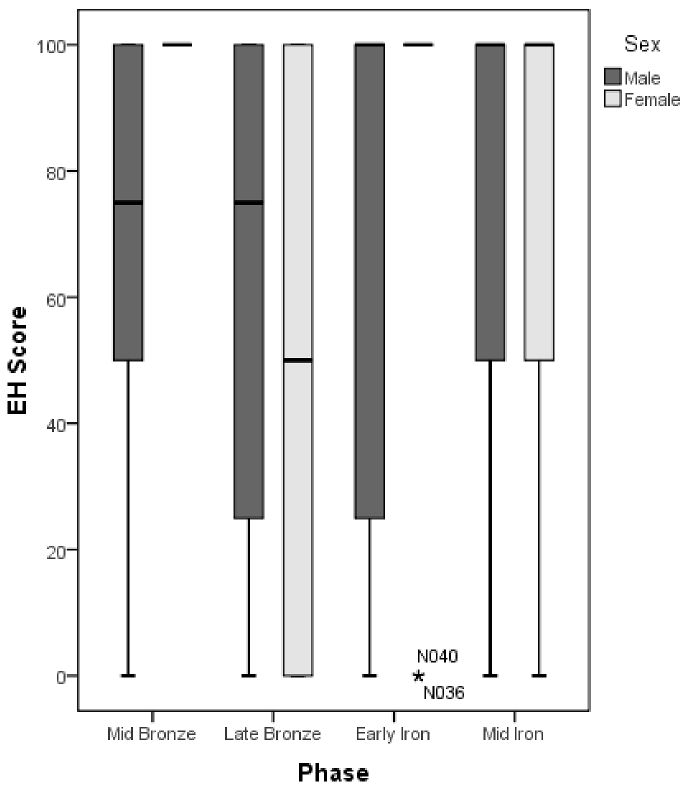

Figure 84: Boxplot of EH scores according to sex and phase.

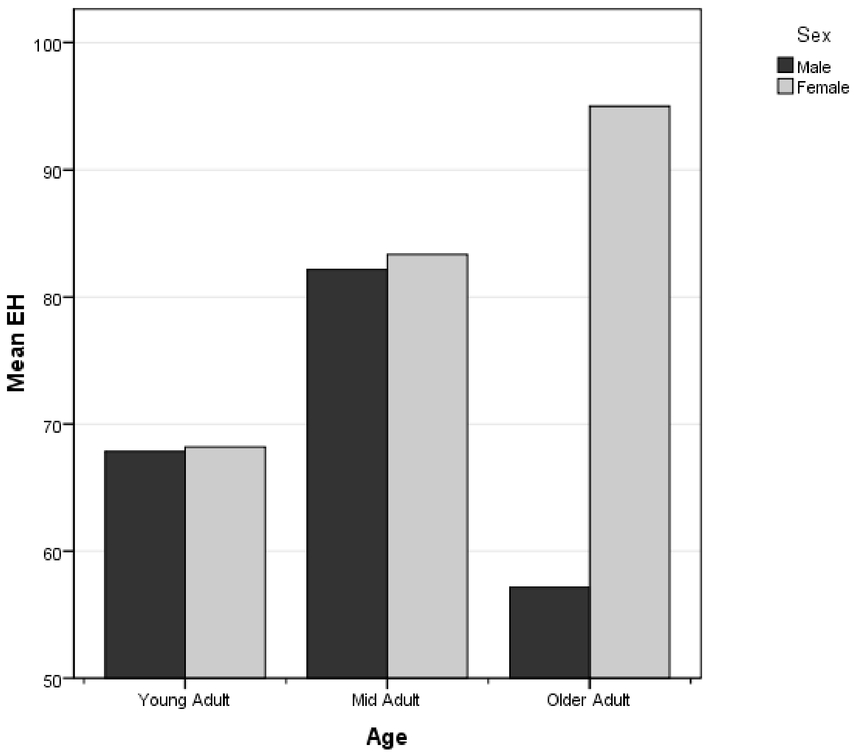

Figure 85: Mean EH score according to age and sex.

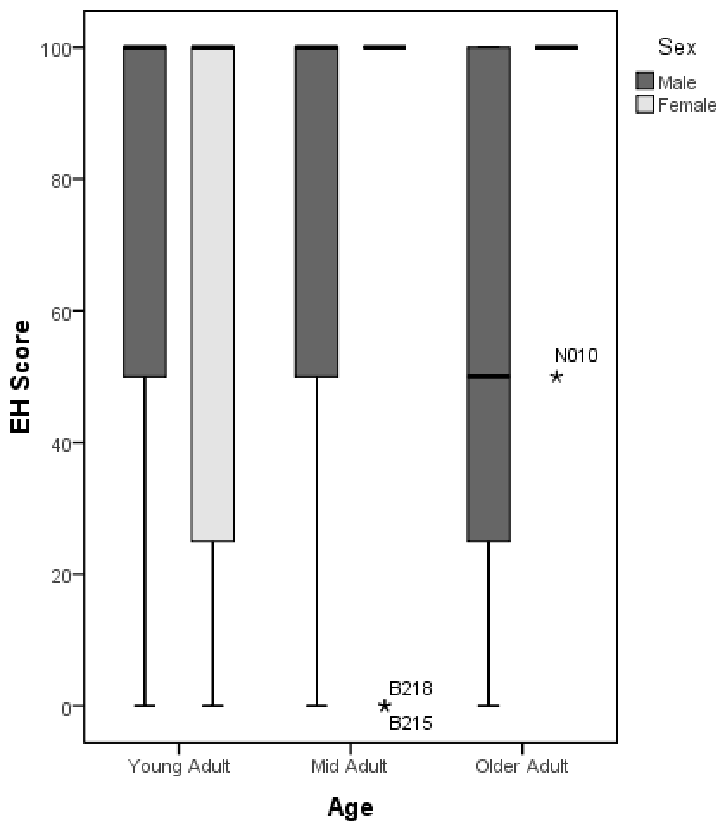

Figure 86: Boxplot of EH Score according to age and sex.

5.1.5 Joint Disease

Joint disease appears more evident in Ban Non Wat than Noen U-Loke (Figure 87). There is a statistical significance in the difference between the two sites (t[73]= -3.540, $p<0.05$). The boxplot, in Figure 88, visually shows the difference between the two sites. The median for NUL is 100, which signifies that an individual had no DJD, and any score less than that is considered to be an outlier. This result is considered unusual for any prehistoric site. Therefore, this result is undoubtedly due to the poorer quality skeletons that date to the Iron Age. The difficulty in identifying joint disease in the sample would have an effect on the score.

The joint disease mean of the three age groups can be seen in Figure 89. The configuration of mean scores follows the expected pattern, that is an increase in joint disease from young to older adult. When compared using an one-way Anova, there is no significant difference between the age groups ($F[2,72] = 2.836$, $p>0.05$). When the two sites are distributed according to age groups, Noen U-Loke follows an expected pattern of the prevalence and degree of DJD increasing with age (Figure 90). Within Ban Non Wat, however, young adults have a lower than expected mean score. Studies have shown that the prevalence and degree of DJD increases with age (van Saase et al., 1989). Within the combined sample of Ban Non Wat and Noen U-Loke, there are no significant differences between the age groups relating to joint disease ($F[2,72]=2.836$, $p>0.05$). A Tukey HSD test does show that statistically, young adults and older adults are different, but not significantly so (Table 29). Isolating the Ban Non Wat sample, there is also no significant difference between the joint disease mean of age groups at Ban Non Wat ($F[2,35]=0.990$, $p>0.05$). Variance at Noen U-Loke for joint disease according to age groups is different and a Kruskal-Wallis Test was undertaken. There are no statistical differences between age groups ($\chi^2[2,\underline{N}=37]=5.441$, $p>0.05$).

Figure 91 shows that there is a difference between sites in the age group of young adults ($t[26]= -4.050$, $p<0.05$), as well as mid adults ($t[29]= -2.189$, $p<0.05$), but older adults appear to be similar.

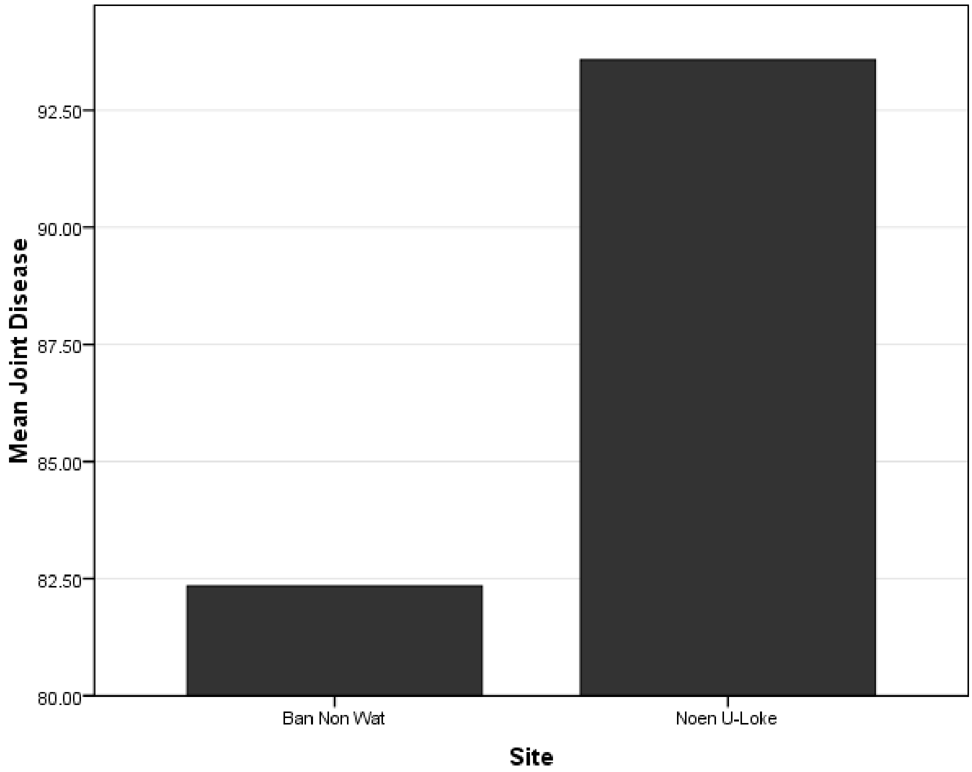

Figure 87: Comparison of joint disease mean scores between Ban Non Wat and Noen U-Loke.

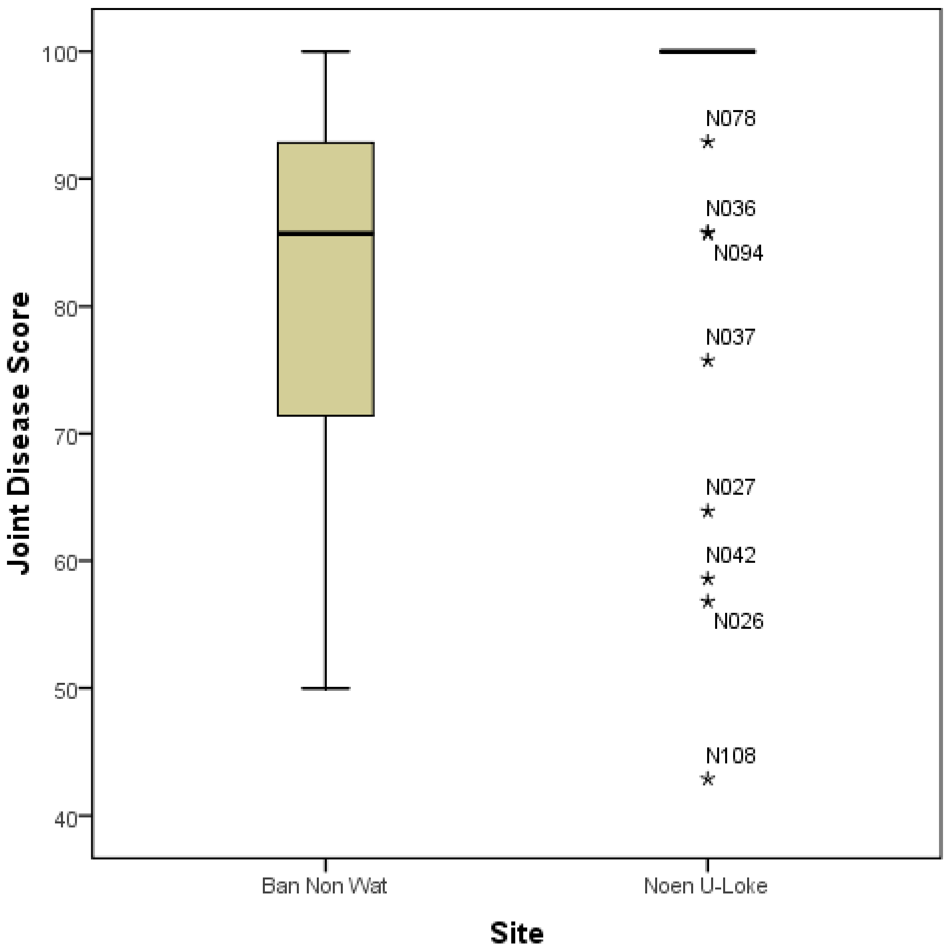

Figure 88: Boxplot of joint disease score according to site.

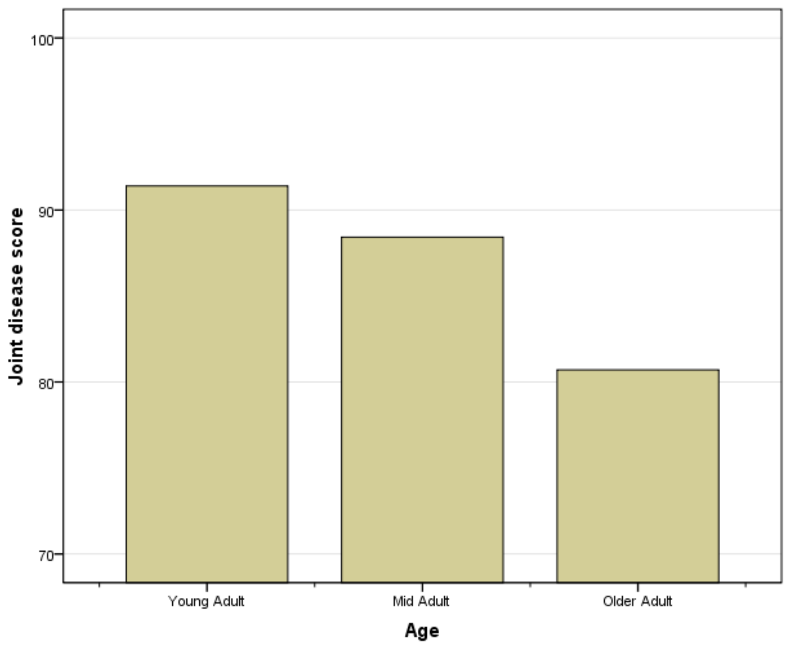

Figure 89: Mean joint disease score according to age at Noen U-Loke and Ban Non Wat.

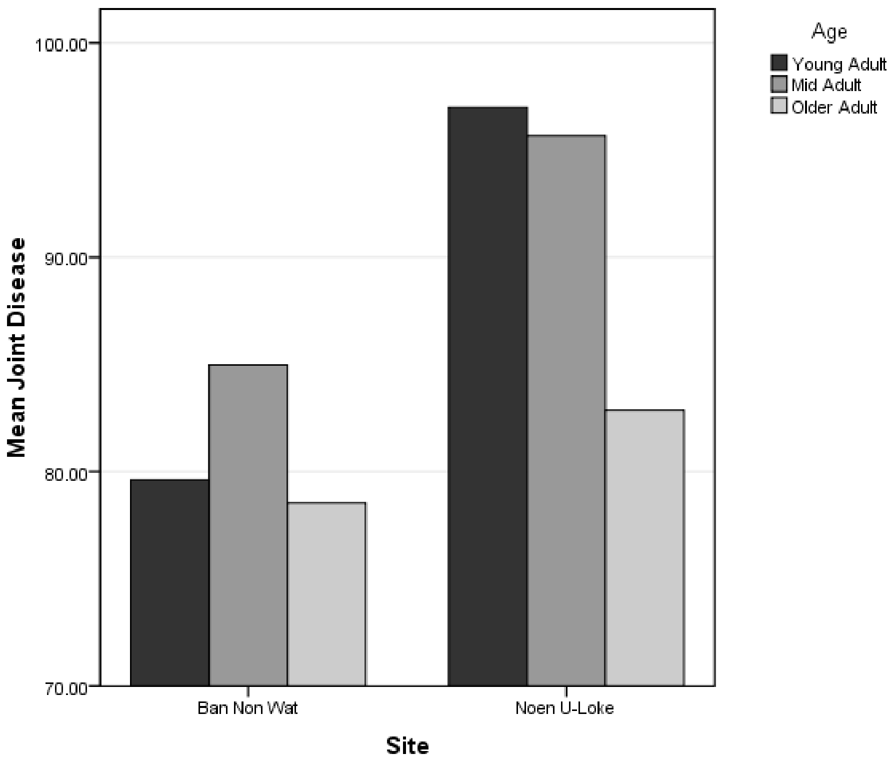

Figure 90: Joint disease mean according to age and location.

In general, there is a decrease in joint disease over time (Figure 92). The Mid Bronze Age appears distinctly different to the other phases (Figure 92 and Figure 93). Comparison of young adults within the four different phases found that there was a statistically significant difference between them (χ^2[3,N=28] =12.974, p<0.05), although due to a non-parametric test being required, the exact nature of the difference is unknown. A similar result was found for mid adults (F[3,27]= 4.207, p<0.05), and a Tukey HSD test identified that the difference lies between the Mid Bronze and the Mid Iron Age for mid adults. It is likely that the scores are being skewed positively towards Noen U-Loke due to the poor condition of the bone and particularly the articular joints. There was no difference between older adults within the different phases (F[3,12]=1.818, p>0.05). There is no statistical difference between the age groups in the Mid Bronze Age (F[2,10]= 0.258, p>0.05); Late Bronze Age (F[2,6]= 0.212, p>0.05), Early Iron Age (F[2,27]= 1.334, p>0.05) or Mid Bronze Age (χ^2[2,N=27] =1.7, p>0.05).

Table 29: One Way Anova Tukey HSD Test of individuals from Ban Non Wat and Noen U-Loke according to age.

(I) AGE	(J) AGE	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					LOWER BOUND	UPPER BOUND
Young adult	Mid adult	2.97263	3.75923	.710	-6.0237	11.9689
	Older adult	10.69202	4.51876	.053	-.1219	21.5060
Mid adult	Young adult	-2.97263	3.75923	.710	-11.9689	6.0237
	Older adult	7.71939	4.43854	.198	-2.9026	18.3414
Older adult	Young adult	-10.69202	4.51876	.053	-21.5060	.1219
	Mid adult	-7.71939	4.43854	.198	-18.3414	2.9026

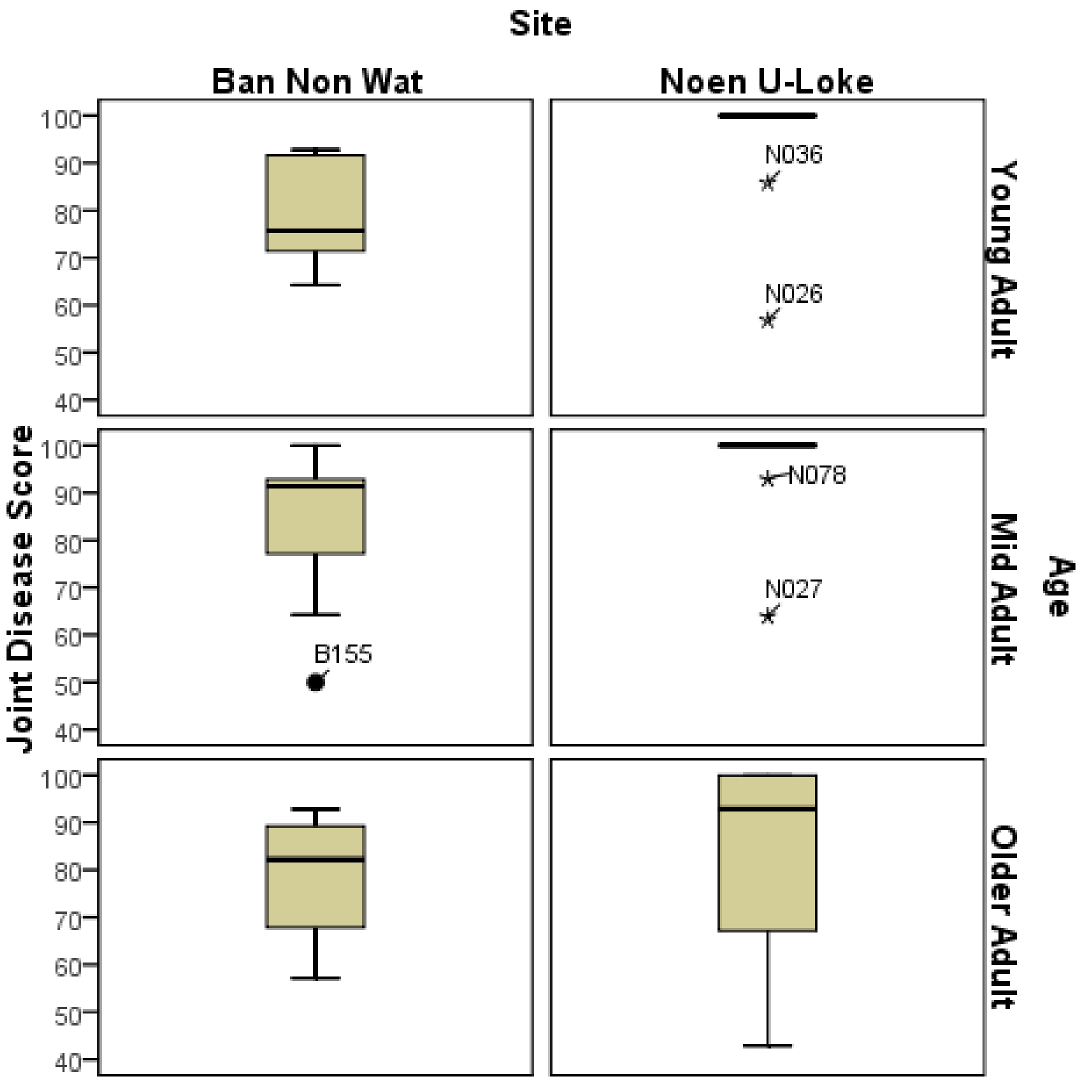

Figure 91: Boxplot of joint disease scores for adults according to location and age.

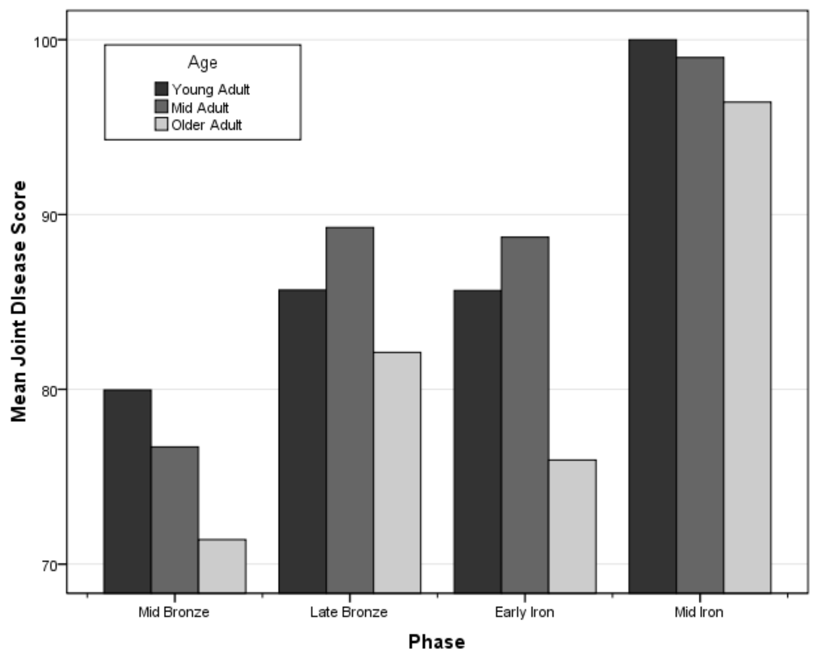

Figure 92: Mean joint disease score according to phase and age.

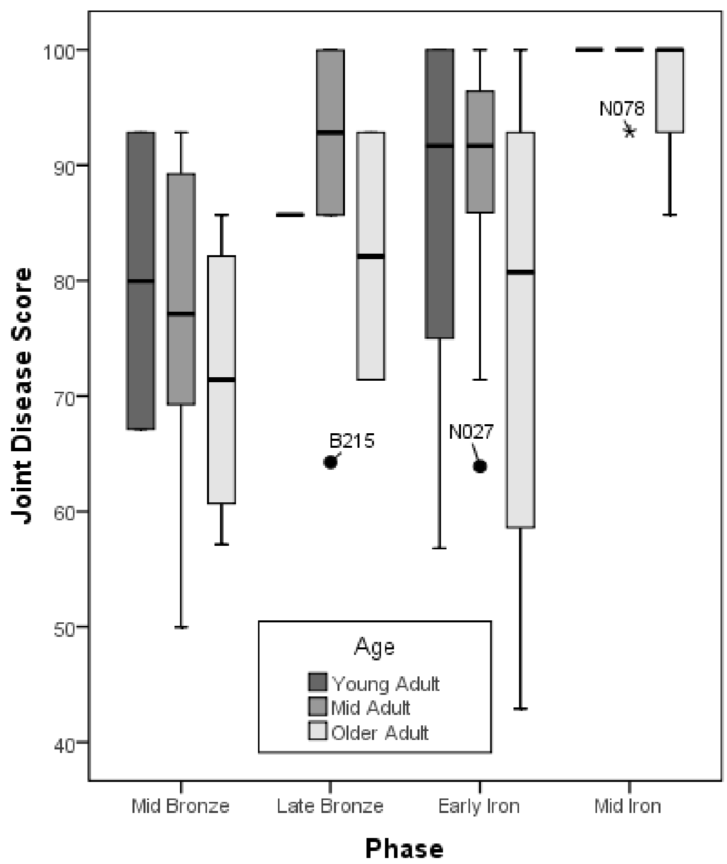

Figure 93: Boxplot of joint disease scores according to age and phase.

Overall, females have a lower score for joint disease. Table 30 shows the average joint disease score for sexes in Ban Non Wat and Noen U-Loke. There is no statistical difference between the two groups (t[62] = 0.538, p>0.05).

Table 30: Mean score for Joint Disease by sex.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Joint Disease	Male	34	87.6601	15.22	2.61
	Female	30	85.5806	15.65	2.86

Within the site of Ban Non Wat, there was little difference between males and females with regard to joint disease (Table 31). An independent t-test shows similarity between males and females at Ban Non Wat (t[31] = 0.449, p>0.05).

Table 31: Mean of Joint Disease score by sex at Ban Non Wat.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Joint Disease	Male	16	82.2164	13.33708	3.33427
	Female	17	80.1752	12.77031	3.09726

As with Ban Non Wat, there was little difference in the mean score of males and females at Noen U-Loke (Table 32) (t[29] = -0.26, p>0.05). Comparing males from Noen U-Loke and Ban Non Wat shows a difference in the boxplot (Figure 94). There is a statistically significant difference between males in the two samples (t[32]=-2.061, p<0.05). There is a similar result between females of Ban Non Wat and Noen U-Loke (t[28]= -2.321, p<0.05).

Table 32: Means of joint disease score at Noen U-Loke according to sex.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Joint Disease	Male	18	92.4989	15.48577	3.65003
	Female	13	92.6492	16.70369	4.63277

The Mid Iron Age had a higher mean score of joint disease that earlier phases (Figure 95). There is a significant difference in joint disease according to time phase. Variance is different; therefore a Kruskal-Wallis Test was undertaken (χ^2[3,N=75]= 34.666, p<0.05). A Tukey test shows that the difference is between the Mid Iron Age and both the Mid Bronze Age and Early Iron Age (Table 33). However, this may be the product of poor joint availability and not a reduction of DJD in time.

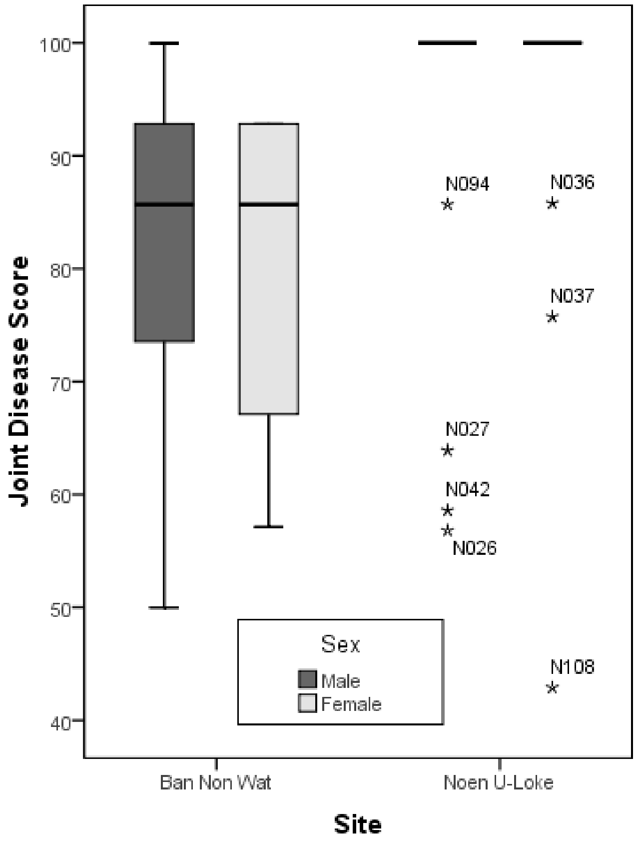

Figure 94: Boxplot of joint disease scores by sex and location.

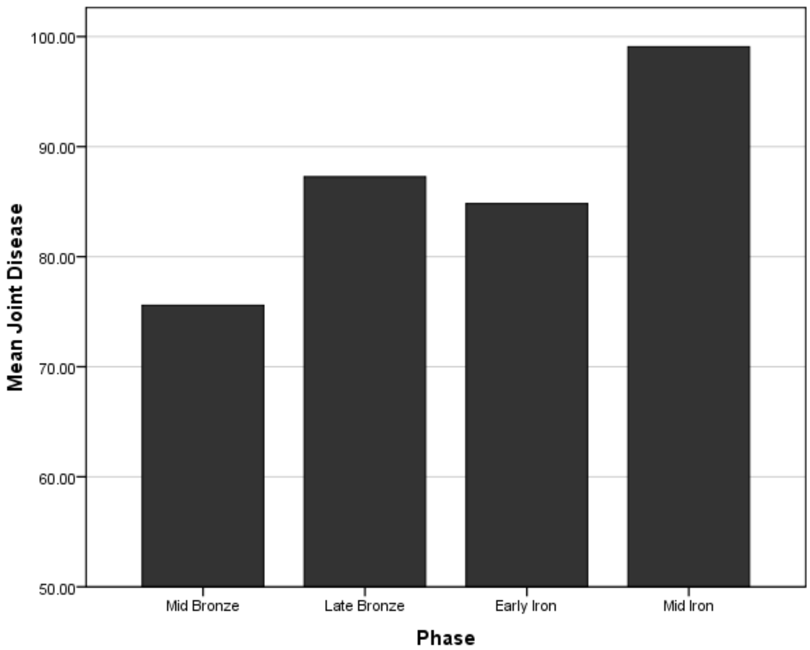

Figure 95: Mean score of joint disease at Ban Non Wat and Noen U-Loke based on time phase.

Table 33: Tukey HSD test of joint disease in regards to phase at Ban Non Wat and Noen U-Loke.

(I) PHASE	(J) PHASE	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					LOWER BOUND	UPPER BOUND
Mid Bronze	Late Bronze	-11.69696	5.40166	.143	-25.9084	2.5145
	Early Iron	-9.25456	4.13629	.123	-20.1369	1.6278
	Mid Iron	-23.49541*	4.32240	.000	-34.8674	-12.1235
Late Bronze	Mid Bronze	11.69696	5.40166	.143	-2.5145	25.9084
	Early Iron	2.44240	4.73434	.955	-10.0133	14.8981
	Mid Iron	-11.79845	4.89778	.085	-24.6842	1.0873
Early Iron	Mid Bronze	9.25456	4.13629	.123	-1.6278	20.1369
	Late Bronze	-2.44240	4.73434	.955	-14.8981	10.0133
	Mid Iron	-14.24085*	3.45241	.001	-23.3239	-5.1578
Mid Iron	Mid Bronze	23.49541*	4.32240	.000	12.1235	34.8674
	Late Bronze	11.79845	4.89778	.085	-1.0873	24.6842
	Early Iron	14.24085*	3.45241	.001	5.1578	23.3239

*. The mean difference is significant at the 0.05 level.

Figure 96 splits the phases into the different sites. The Early Iron Age is the only phase that encompasses both locations. Following the calculation of a chi square test, it was found that there is a significant difference between Noen U-Loke and Ban Non Wat in the Early Iron Age (χ^2 [17,N=30] =30.00, $p<0.05$).

All phases show a minor difference in joint disease mean scores between sexes, although the Late Bronze Age shows a larger difference (Figure 97) This difference is not statistically significant (t[6]=0.816, $p>0.05$). There are significant differences between males from the Mid Bronze Age and Mid Iron Age (χ^2[3,N=34]=15.946, $p<0.05$). This is the same case for females (χ^2[3,N=30]=11.582, $p<0.05$). There are no other significant differences between phases for each sex.

The Early Iron Age is the only phase that Ban Non Wat and Noen U-Loke can be directly compared. There appears to be a larger difference between the males of the two sites than the females (Figure 98). There is no statistical difference, however, between males (χ^2 [6,N=11] =11, $p>0.05$) or between females (t[13]= -0.479, $p>0.05$).

Figure 99 reveals very little difference between males and females who are mid aged, but some difference for young adults and older adults. These differences are not statistically significant (young adults t[21]=1.486, $p>0.05$; older adults t[14]= -0.577, $p>0.05$).

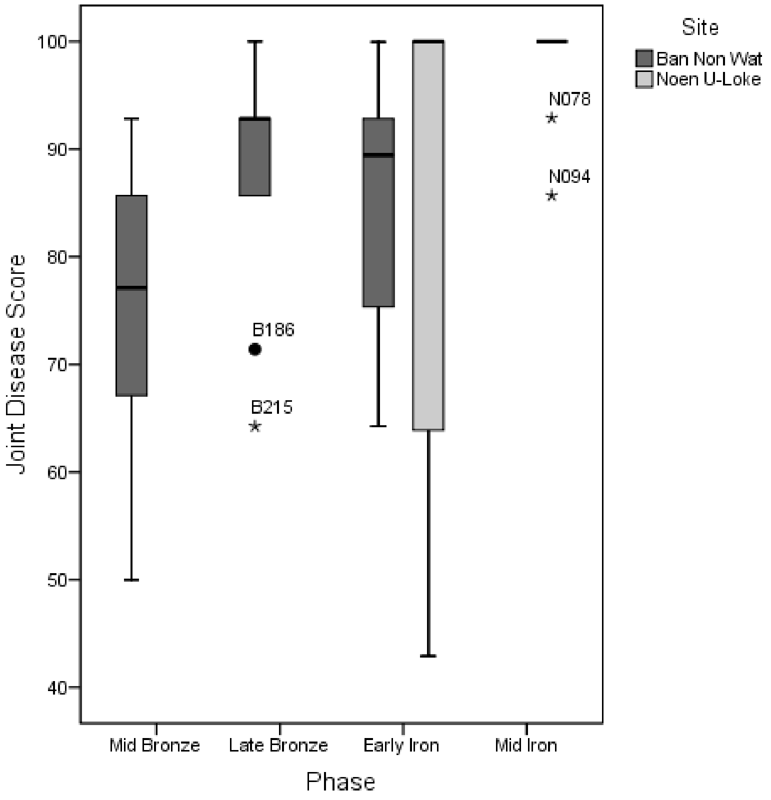

Figure 96: Boxplot showing joint disease scores according to phase and location.

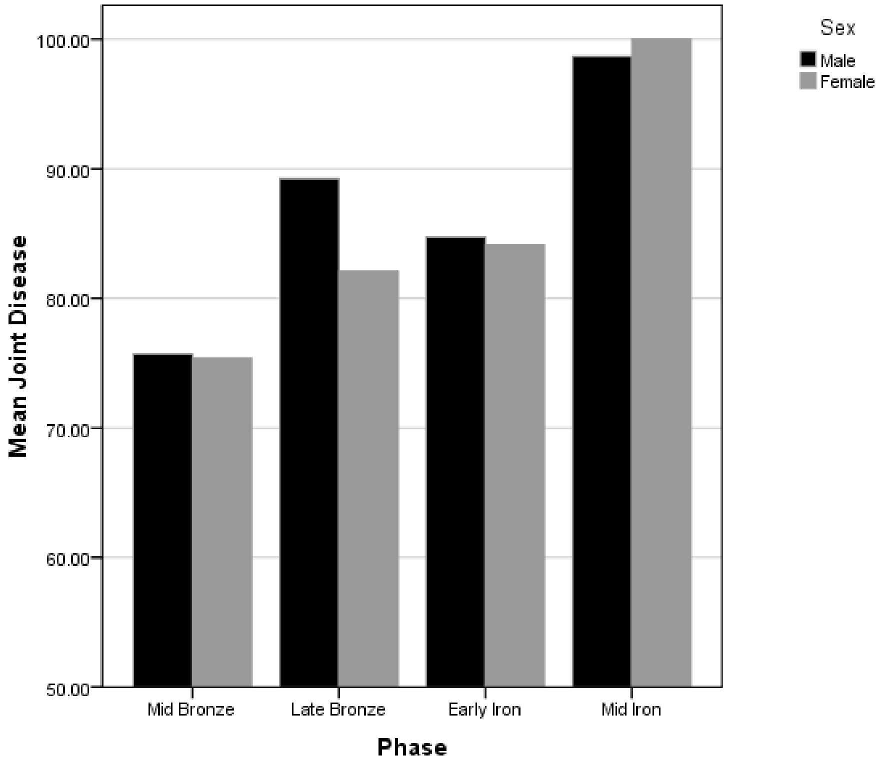

Figure 97: Mean Joint Disease score according to sex and phase at Ban Non Wat and Noen U-Loke.

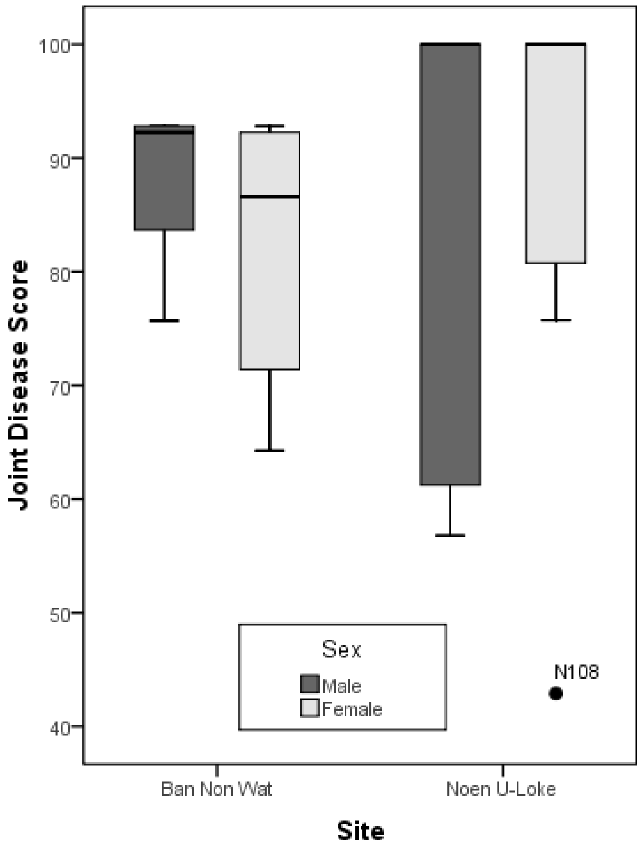

Figure 98: Boxplot of the Early Iron Age - joint disease score according to site and sex.

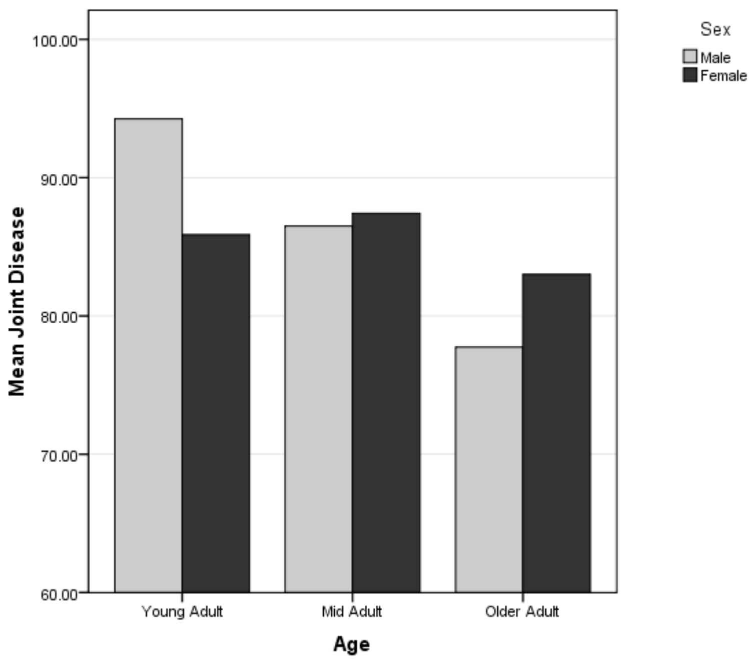

Figure 99: Joint disease means according to age and sex in Ban Non Wat and Noen U-Loke.

5.1.6 Childhood Lesions

No childhood lesions relating to porotic hyperostosis or cribra orbitalia were found in the adult samples from Ban Non Wat and Noen U-Loke. This does not necessarily mean that conditions that form these bony changes in childhood were not present in the population. It may mean that these adults did not contract any condition that caused severe porotic reaction in the skull or orbits. A small number of sub-adults from Noen U-Loke have been identified as having porotic hyperostosis, although none had cribra orbitalia (Halcrow, 2006). Other factors are the quality of skeletal material available with the skeletons dating from the Iron Age period being in particularly poor condition and the delicate nature of orbits does not allow a high survivability. Nevertheless, the adults in the sample did not have any childhood lesions and all scored the highest possible score as a result. Accordingly there is no comparative analysis amongst sub-groups, such as sex, phase or location.

5.1.7 Pathology

The means scores for pathology shows that the sample from Noen U-Loke has less pathological severity overall than Ban Non Wat (Table 34), and the box plot also shows this, but the median is not largely different (Figure 100). The difference between the two sites is not statistically significant ($t[79]=-1.015$, $p>0.05$).

Table 34: Mean pathology according to location.

	SITE	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Pathology	Ban Non Wat	38	81.5771	21.24248	3.44599
	Noen U-Loke	43	87.7076	31.41951	4.79143

The mean pathology score for age across both Ban Non Wat and Noen U-Loke shows the lowest score is assigned to the mid adult group and the highest score to older adults (Figure 101). All age groups have outliers (Figure 102), and appear to be similar in range, although the median is lower for mid adults. A one-way ANOVA confirms the similarities ($F[2,78]= 0.839$, $p>0.05$).

When the sites are separated, they appear to be different according to age (Figure 103 and Figure 104). In Ban Non Wat, mid aged adults have a lower pathology score than younger and older adults (Figure 103). This difference, in the Ban Non Wat sample is statistically significant ($\chi^2[2,\underline{N}=38]=8.083$, $p<0.05$). There is no statistical difference between the age groups in Noen U-Loke ($F[2,40]= 0.208$, $p>0.05$). There is a statistical significance between mid adults in Noen U-Loke and Ban Non Wat ($t[32]=-2.183$, $p<0.05$), but not between the young adults ($t[28]=0.316$, $p>0.05$) or the older adults ($t[15]=0.612$, $p>0.05$). People who survived to mid adult age had more pathological lesions than younger or older individuals on average. This does not indicate that they died of these pathologies, but may have had an impact on their life. On average, older adults had a higher pathology score, indicating that older adults did not have any chronic conditions that affected the bone, which may be why they survived to old age.

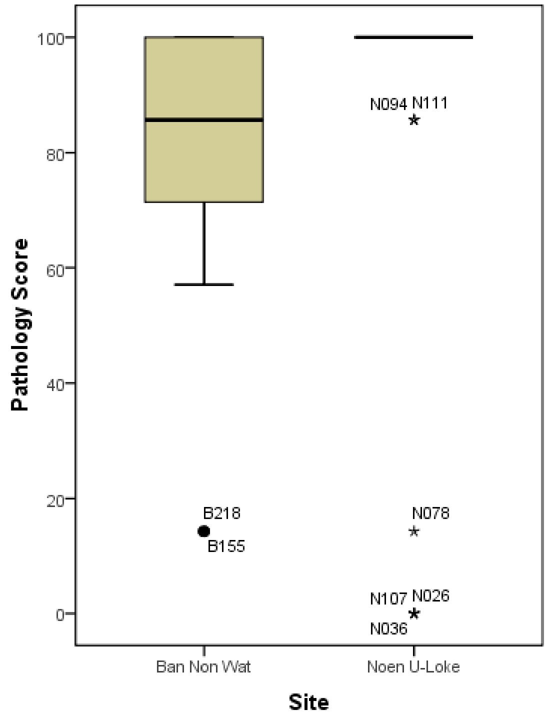

Figure 100: Boxplot of pathology score according to location.

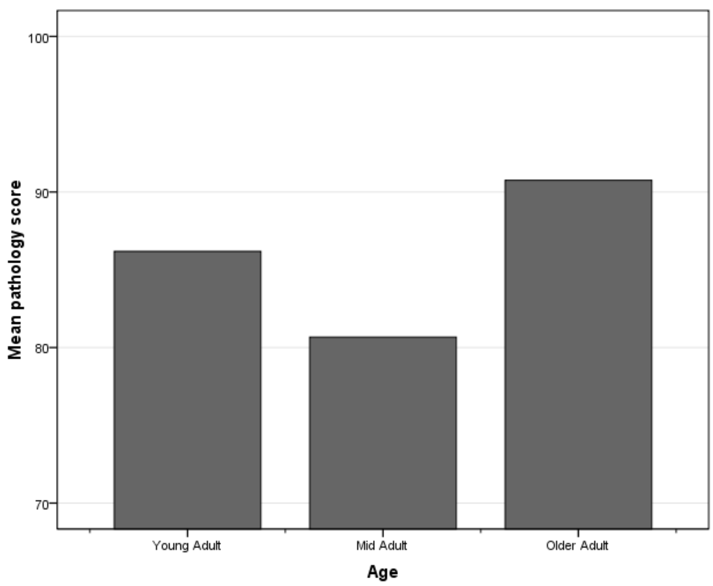

Figure 101: Mean pathology score according to age group.

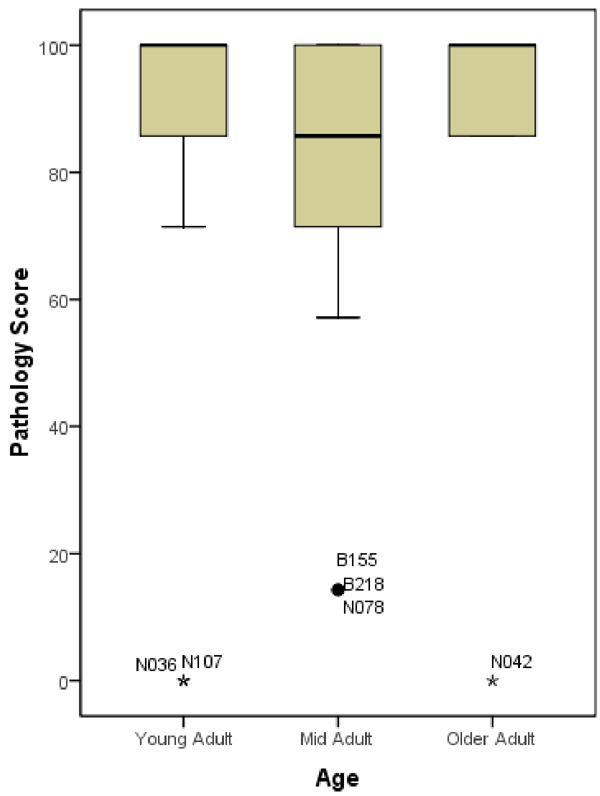

Figure 102: Boxplot of the pathology score according to age group.

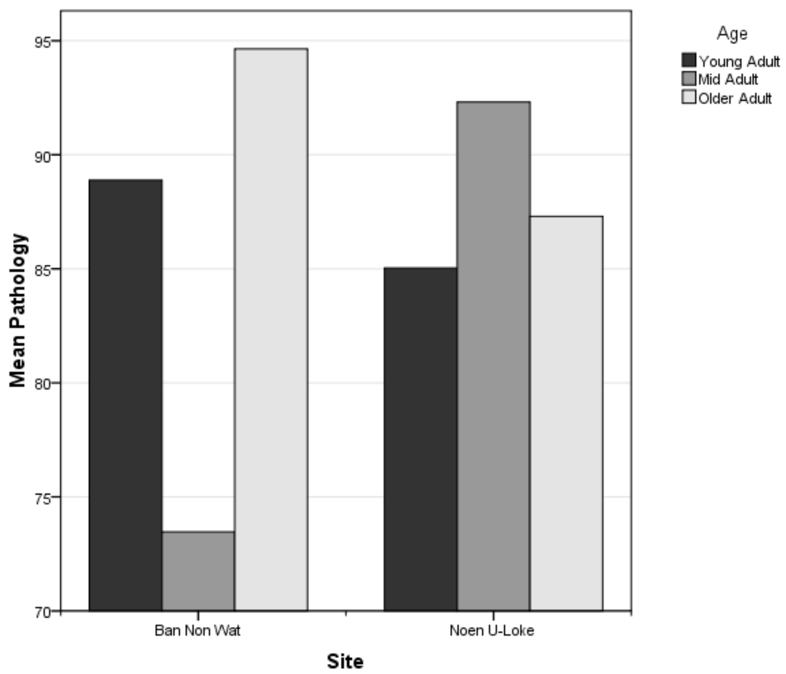

Figure 103: Mean Pathology score according to location and age.

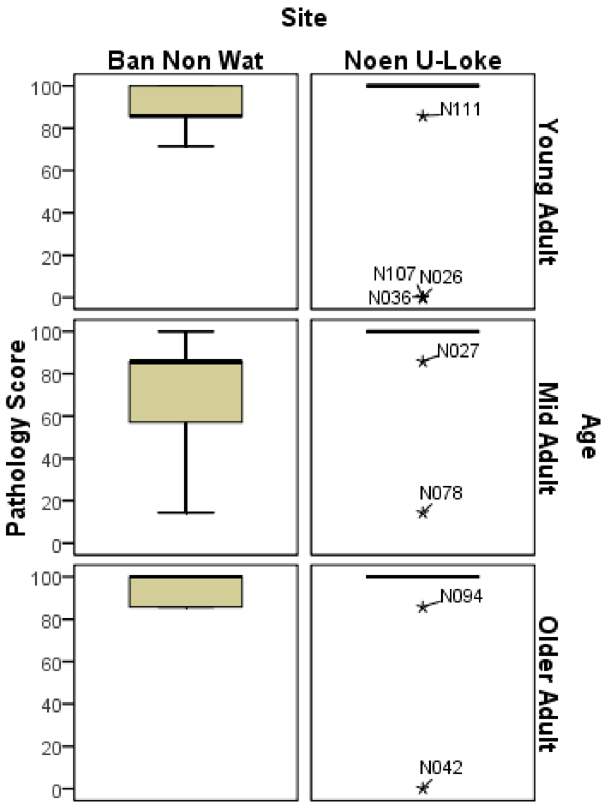

Figure 104: Boxplot of pathology score according to age and location.

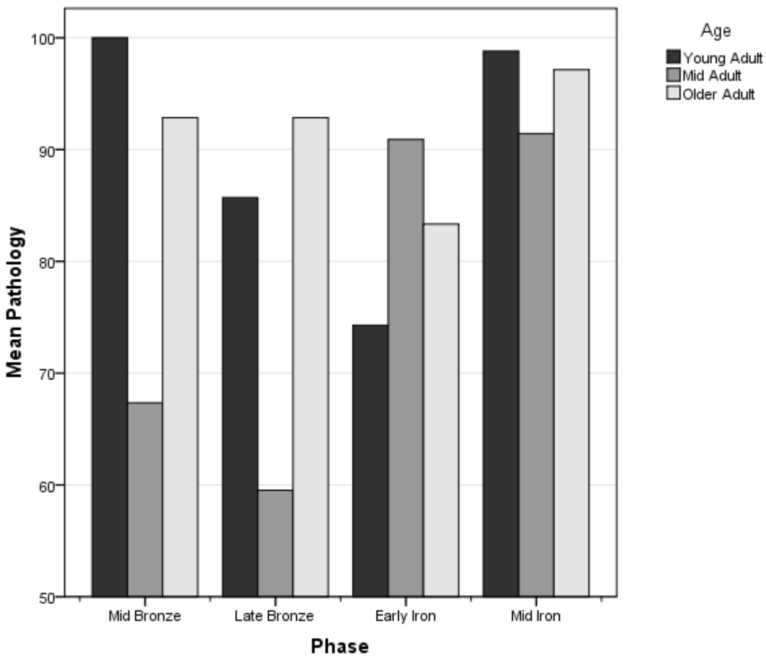

Figure 105: Mean pathology score according to phase and age.

Looking at age groups in the different phases, it can be seen that mid adults have a particular poor score compared to other age groups, especially in the Bronze Age and young adults have their poorest mean score for pathology in the Early Iron Age (Figure 105). Table 13 shows the distribution of age groups within phases. Comparing the means of mid adults between phases, there is a statistically significant difference ($F[3,30]=3.958$, $p<0.05$). The difference cannot be identified in the non-parametric test, but may be related to generally poorer pathology scores for mid adults in the Bronze Age compared to the Iron Age (Figure 106). A one-way ANOVA for older adults in the different phases shows that there is no significant difference between them ($F[3,13]=0.276$, $p>0.05$), however there is a significant difference amongst young adults in the different phases ($\chi^2[3,\underline{N}=30]=9.230$, $p<0.05$). As the young adult significance assessment used a non-parametric test (Kruskal-Wallis Test) the exact nature of the difference is not apparent. However, by examining the boxplot (Figure 106) and the mean score (Figure 105), the Late Bronze Age and the Early Iron Age appear dissimilar to the earliest and latest phases.

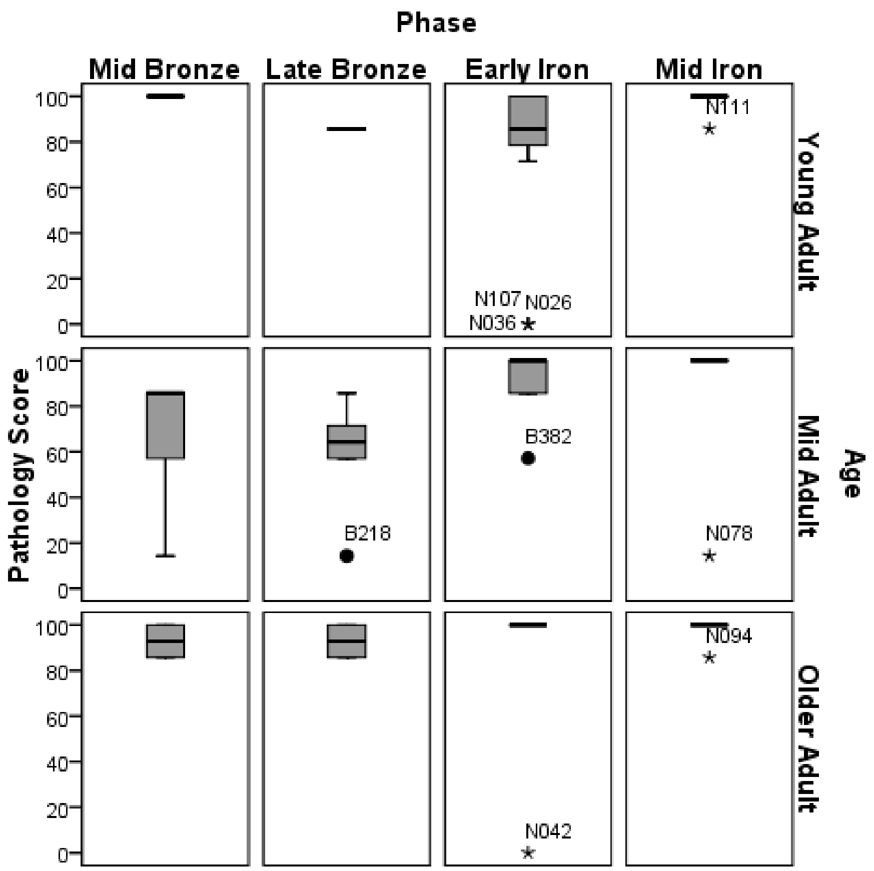

Figure 106: Boxplots of pathology score according to age and phase.

Females have better health relating to the mean pathology score, although the difference is not significant (t[66]= -1.521, p>0.05) (Table 35). Both males and females have outliers (Figure 107), but well over half the females have no pathological lesions (66.7%), whereas male without pathological lesions are just under half (48.6%). When split into the two sites, the pattern of better female pathology score remains (Figure 108), but the site of Noen U-Loke appears to be healthier in regards to pathology scores. Although the range of each of the sexes within each site appear different (Figure 109), there is no significant difference between males and females at Ban Non Wat (t[31]=-1.180, p>0.05), males and females at Noen U-Loke (t[33]=-1.086, p>0.05), between males at both sites (t[33]=-0.404, p>0.05) or between females at both sites (t[31]=-0.907, p>0.05).

Table 35: Comparison of mean pathology score according to sex.

	SEX	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
Pathology	Male	35	79.9992	30.83448	5.21198
	Female	33	90.0424	22.72390	3.95572

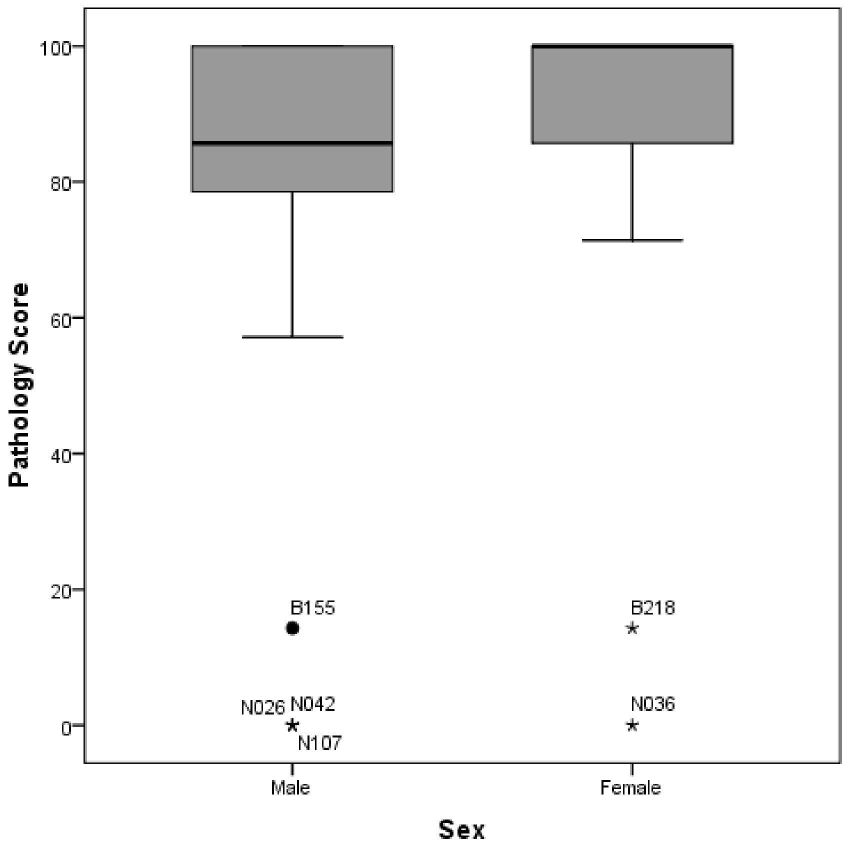

Figure 107: Boxplot of pathology score according to sex.

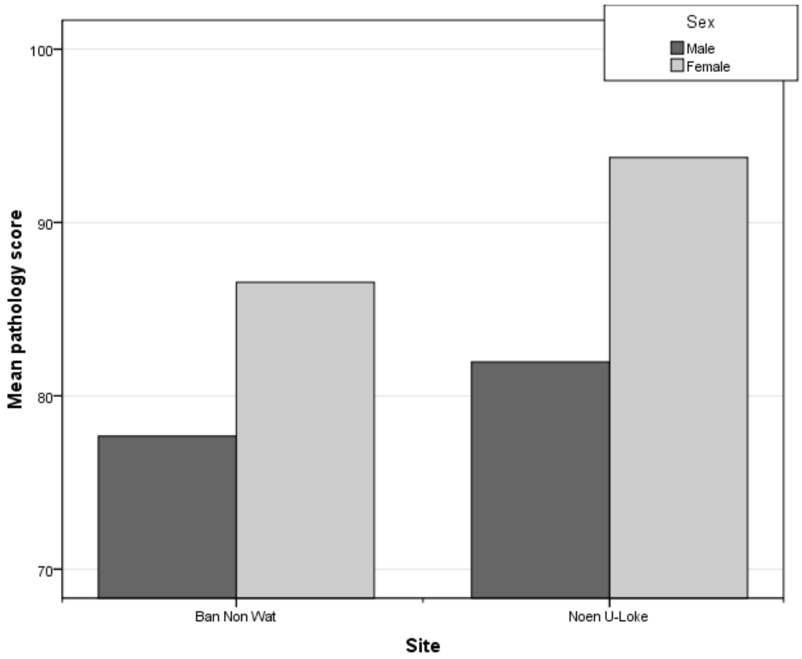

Figure 108: Mean pathology score according to sex and location.

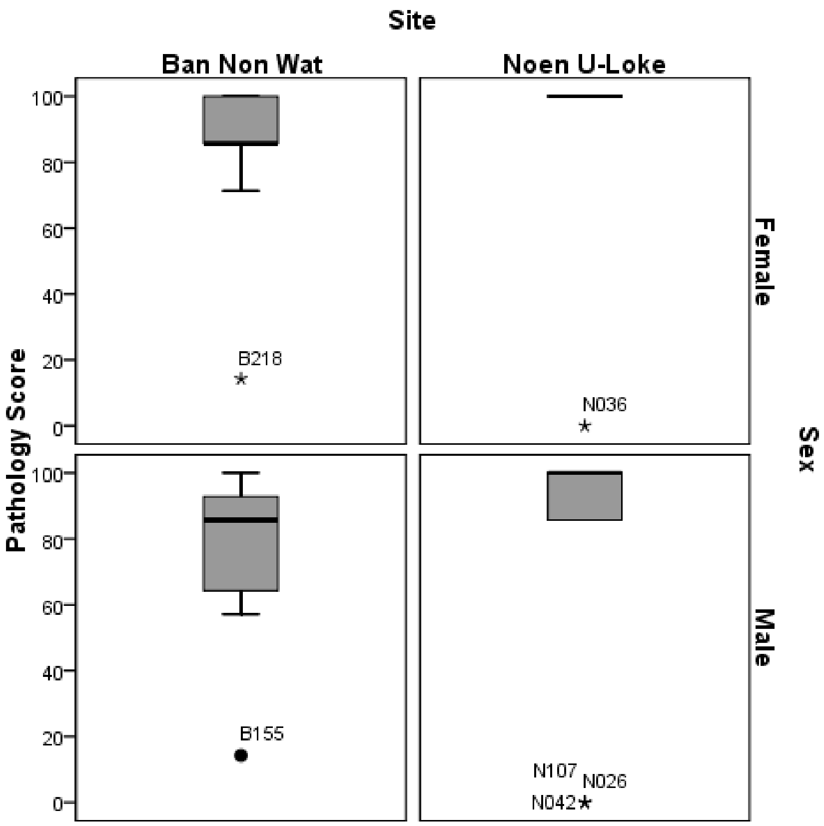

Figure 109: Boxplot of pathology score according to sex and location.

Examination of the mean scores for pathology according to phases shows that the Late Bronze Age has a poorer mean pathology score than any other phase (Figure 110). This difference between the phases is statistically significant ($\chi^2[2,\underline{N}=38]=8.083$, $p<0.05$). As a non-parametric test was used, the exact difference is not apparent, but consideration of the boxplot (Figure 111) shows that there appears to be a larger difference between the Mid Iron Age and the Late Bronze Age. A series of t-tests have shown that the Mid Iron Age is statistically different to the other phases (Table 36).

When the phases are distributed into sites (Figure 112), a pattern similar to that seen in enamel hypoplasia (Figure 81) and dental health (Figure 35) is noted. There is no significant difference between the phases at Ban Non Wat ($F[2,35]=2.676$, $p>0.05$), although there is a significant difference between the Late Bronze Age and Early Iron Age at Ban Non Wat ($t[23]=2.615$, $p<0.05$). A t-test also shows that there is a statistical difference between the Early Iron Age and Mid Iron Age at Noen U-Loke ($t[41]=-2.293$, $p<0.05$). The Early Iron Age is the only phase when Ban Non Wat and Noen U-Loke can be compared (Figure 113). Noen U-Loke has a lower pathology mean score than Ban Non Wat. This difference is statistically significant (χ^2 $[5,N=32]=14.889$, $p<0.05$).

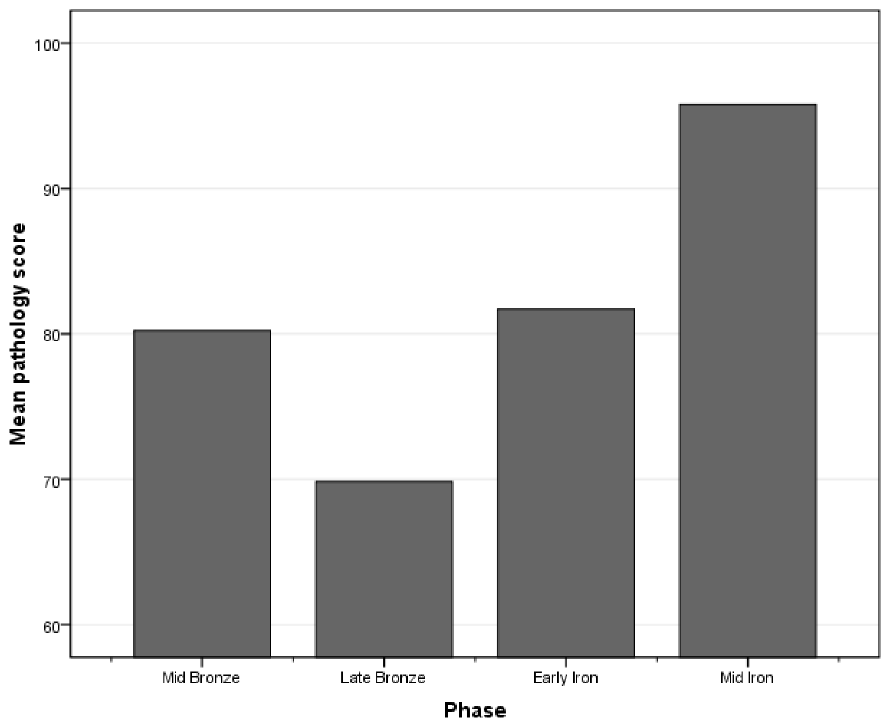

Figure 110: Mean pathology score according to phase.

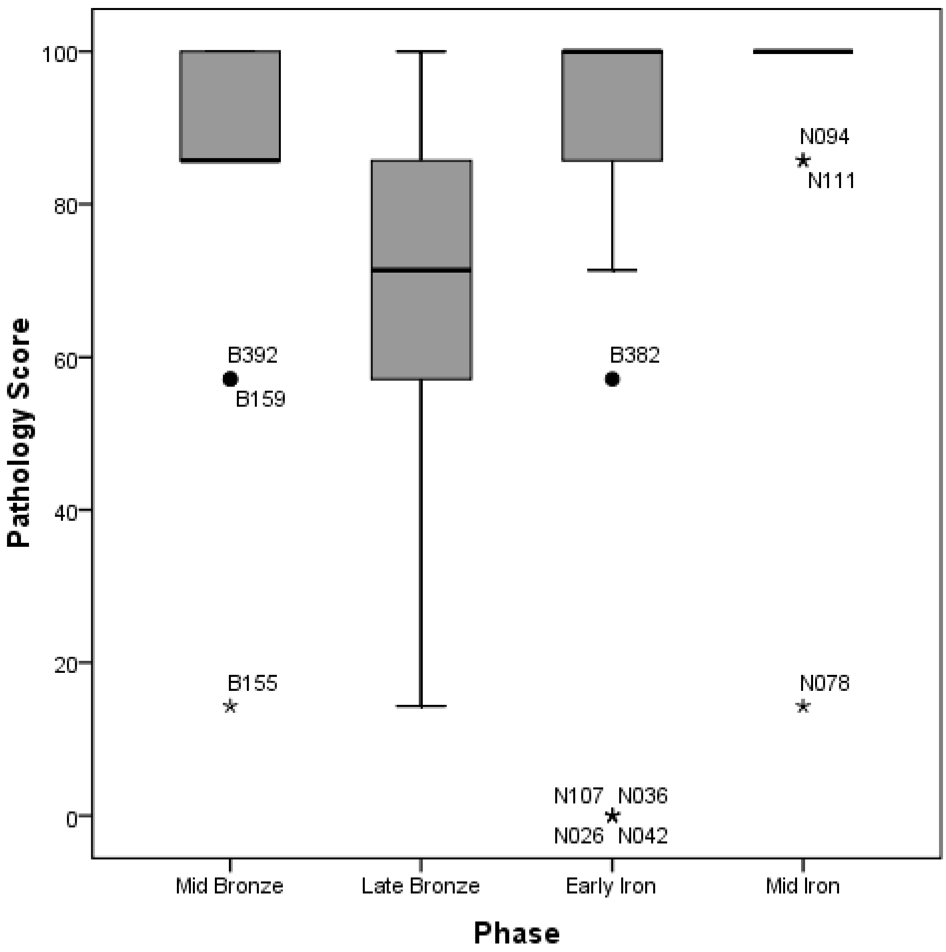

Figure 111: Boxplot of the pathology score according to phase at Noen U-Loke and Ban Non Wat.

Table 36: Pathology score relationships between phases using t-tests.

RELATIONSHIP	T-TEST	SIGNIFICANTLY DIFFERENT RELATIONSHIP
Mid Iron Age vs Early Iron Age	T(57)=-2.012, p<0.05	YES
Mid Iron Age vs Late Bronze Age	T(34)=-3.534, p<0.05	YES
Mid Iron Age vs Mid Bronze Age	T(34)=-2.364, p<0.05	YES
Late Bronze Age vs Early Iron Age	T(39)=0.998, p>0.05	NO
Mid Bronze Age vs Late Bronze Age	T(20)=0.968, p>0.05	NO
Mid Bronze Age vs Early Iron Age	T(43)=-0.146, p>0.05	NO

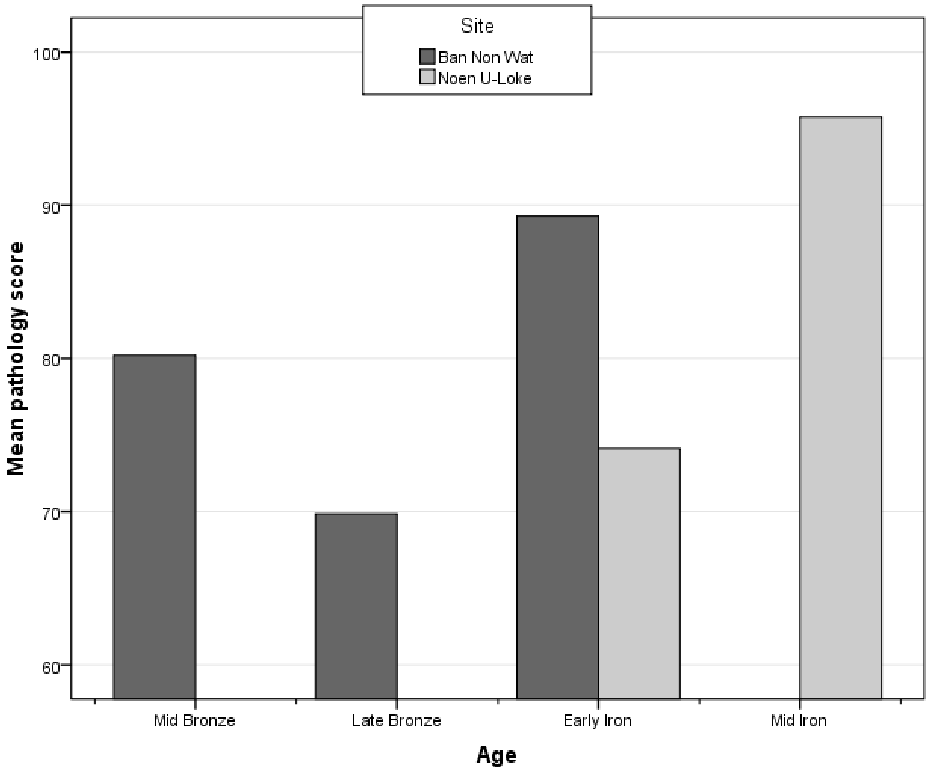

Figure 112: Mean pathology according to site and phase.

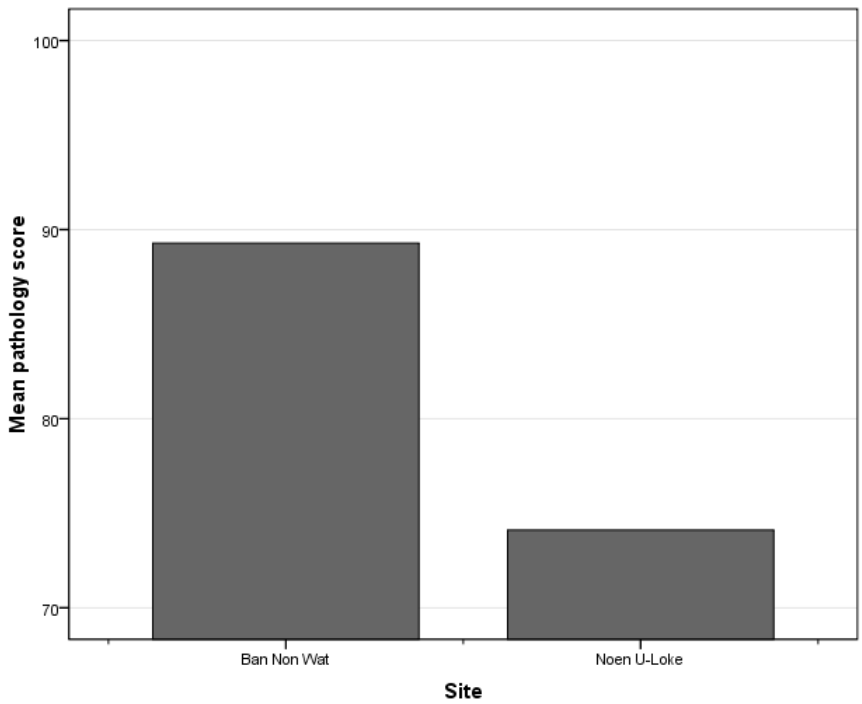

Figure 113: Mean pathology scores in the Early Iron Age according to location.

The general trend through the different phases is that females have less pathology than males, except for the Late Bronze Age, where the trend is reversed (Figure 114). This pattern, which only includes the sample at Ban Non Wat, is similar to the EH pattern seen in Figure 83. There is a significant difference amongst the males in the different phases (χ^2[3,N=35]=10.903, p<0.05), but not amongst the females (F[3,29]=1.948, p>0.05).

Young adult female pathology scores decrease through time until the Mid Iron Age (Figure 114). Older adults have consistently high pathology scores in each phase for both sexes. Mid adults of both sexes improve in pathology score over time, except that females in the Late Bronze Age are markedly poorer in pathology score. The statistically significant difference regarding mid adults seen in Figure 105 appears attributable to the female sample. There is no statistically significant difference between males and females (t[3]=1.2, p>0.05). Examination of the mean and boxplot (Figure 115) shows that the Mid Iron Age is different from other phases for both males and females. The only phase where Ban Non Wat and Noen U-Loke can be directly compared is the Early Iron Age (Figure 116). Although there appear to be differences in the range of sexes in the Early Iron Age (Figure 117), there are no statistically significant differences between males of the two sites in the Early Iron Age (χ^2 [4,N=12] =6.000, p>0.05) or between females (t[14]=0.419, p>0.05).

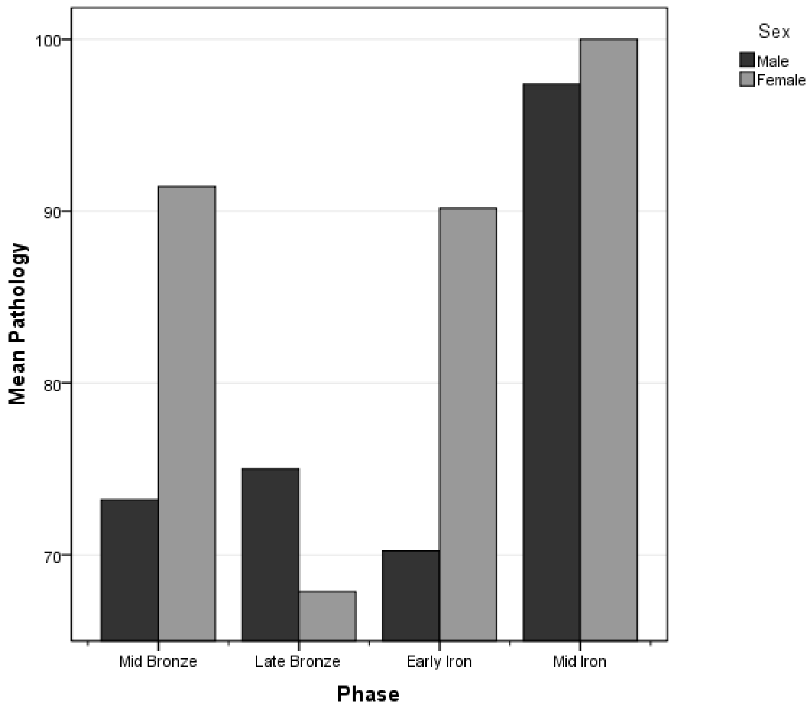

Figure 114: Mean pathology score according to phase and sex.

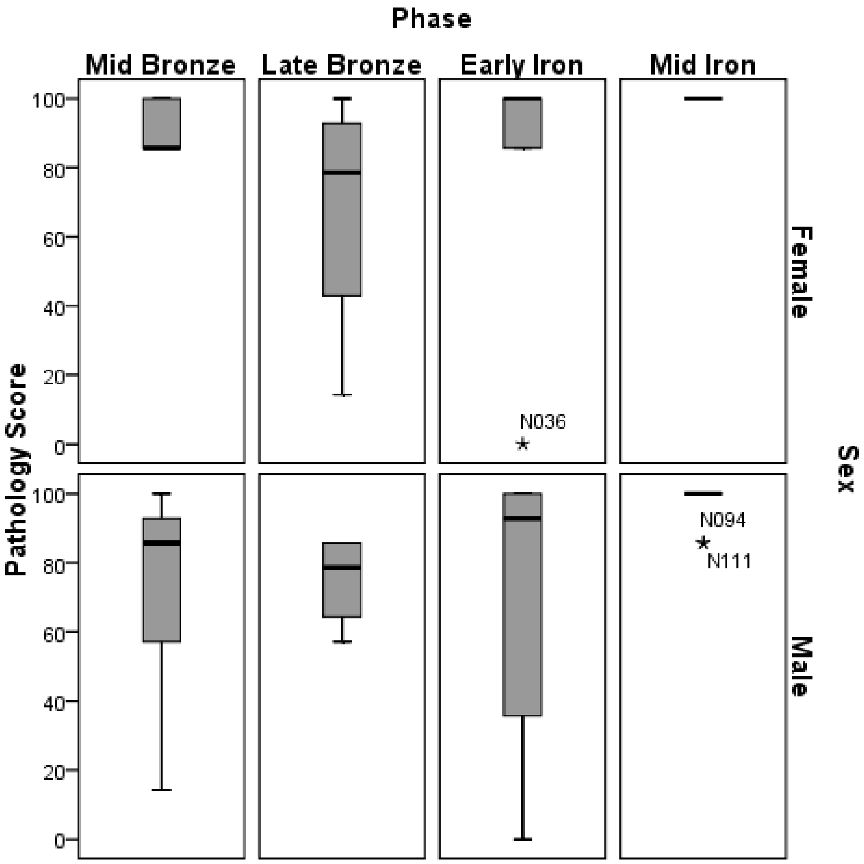

Figure 115: Boxplot of pathology score according to phase and sex at Noen U-Loke and Ban Non Wat.

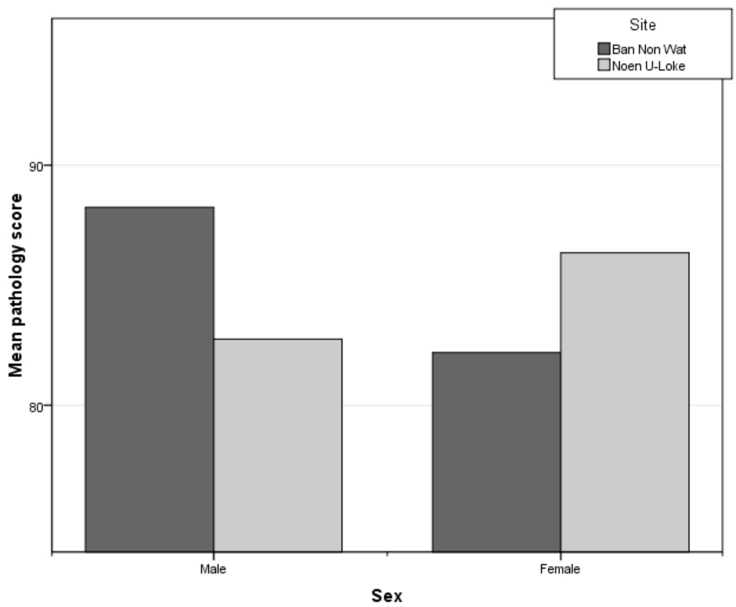

Figure 116: Mean pathology score according to sex and location in the Early Iron Age.

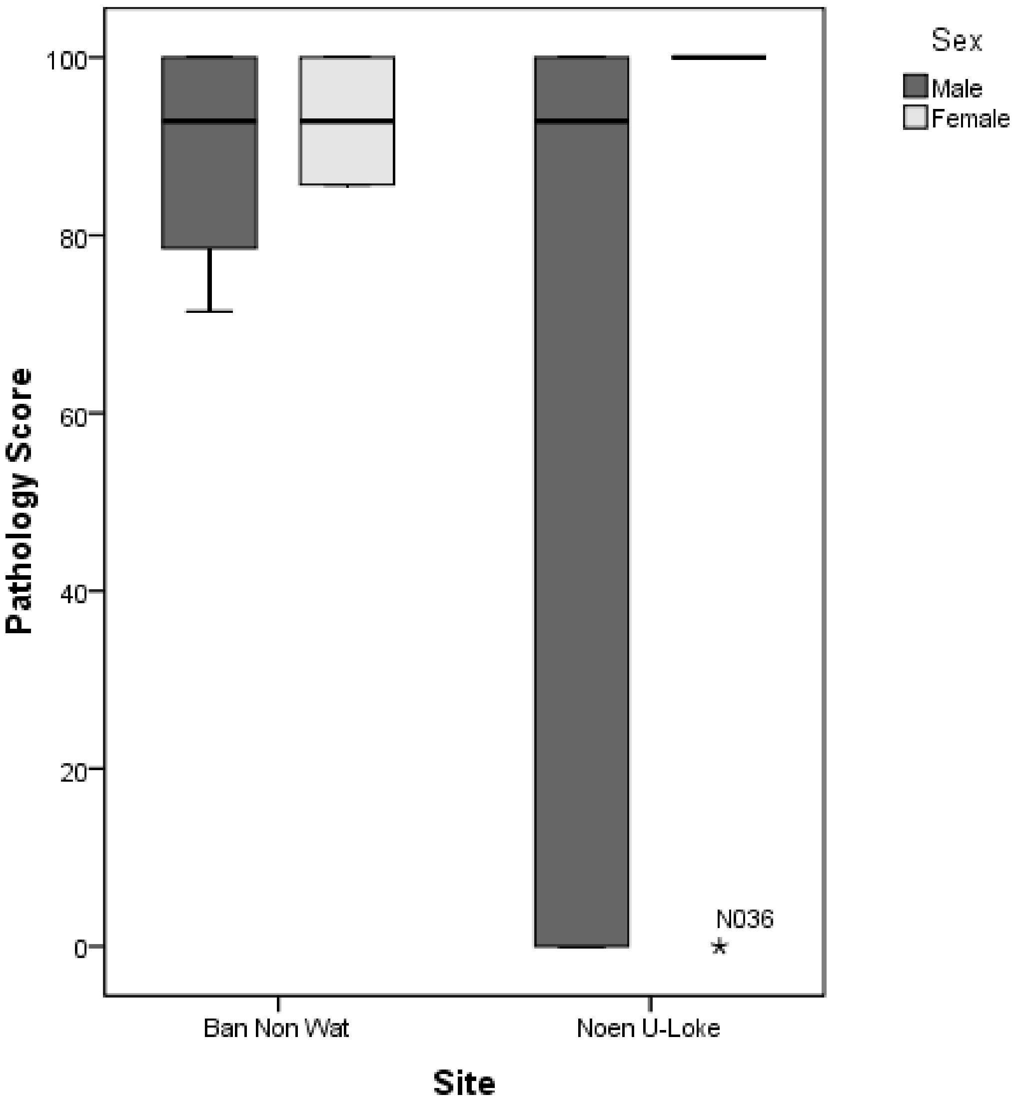

Figure 117: Boxplot of pathology score according to sex and location in the Early Iron Age.

The mean pathology scores of males are similar in each age group (Figure 118). Females of the older adult group, however appear to have little pathology. However, there is no statistically significant difference amongst the females ($F[2,30]=1.020$, $p>0.05$) or the males ($F[2,32]=0.091$, $p>0.05$). In addition, there are no differences between males and females in each age group (young adult males and females $t[23]=-0.229$, $p>0.05$; mid adult males and females $t[24]=-0.972$, $p>0.05$; and older adults males and females $t[15]=-1.680$, $p>0.05$).

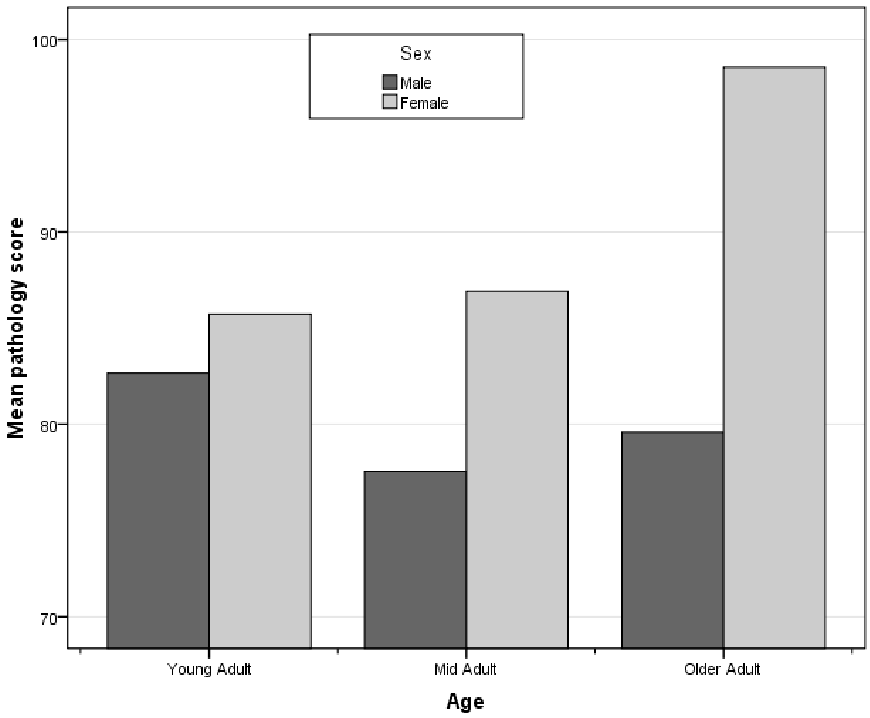

Figure 118: Mean Pathology according to age and sex.

5.1.8 SEAHI

Noen U-Loke has a similar mean to Ban Non Wat, but has a wider range, which includes a number of outliers that have low SEAHI scores (Table 37 and Figure 119). There is no statistically significant difference between Ban Non Wat and Noen U-Loke overall (t[79]=-1.090, p>0.05).

Table 37: Mean SEAHI score according to location.

	SITE	N	MEAN	STD. DEVIATION	STD. ERROR MEAN
SEAHI Score	Ban Non Wat	38	49.6274	2.95668	.47964
	Noen U-Loke	43	50.4725	3.88527	.59250

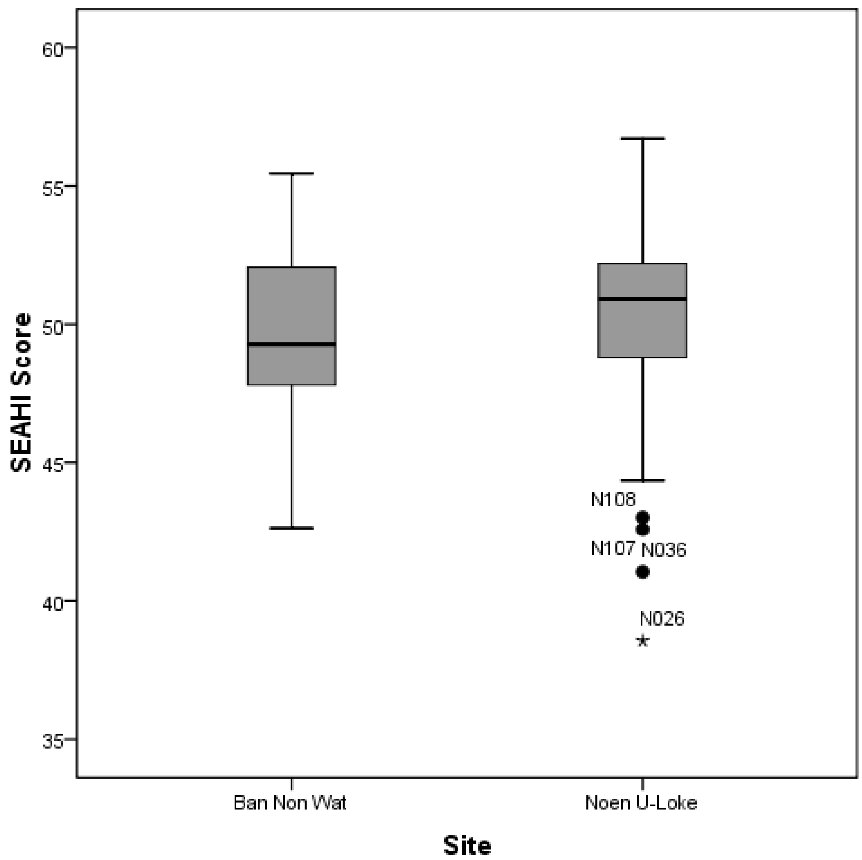

Figure 119: Boxplot of SEAHI scores according to site, outliers included.

There appears to be little difference in SEAHI scores between the age groups (Table 38) ($F[2,53]=0.735$, $p>0.05$).

Table 38: Mean SEAHI scores according to age groups.

AGE	MEAN	N	STD. DEVIATION	RANGE
Young adult	49.7540	30	3.51361	14.21
Mid adult	50.1398	34	3.40422	13.13
Older adult	50.5167	17	3.74892	13.70
Total	50.0760	81	3.48544	16.36

Figure 120 shows a boxplot that separates age groups into Ban Non Wat and Noen U-Loke. There are no significant differences between the age groups in Ban Non Wat ($\chi2[2,N=38]=0.562$, $p>0.05$) or within Noen U-Loke ($F[2,40]=0.245$, $p>0.05$). There are also no differences statistically between young adults at Ban Non Wat and Noen U-Loke ($t[28]=-0.781$, $p>0.05$), or between mid adults ($t[32]=-1.250$, $p>0.05$) or older adults ($t[15]=-0.015$, $p>0.05$).

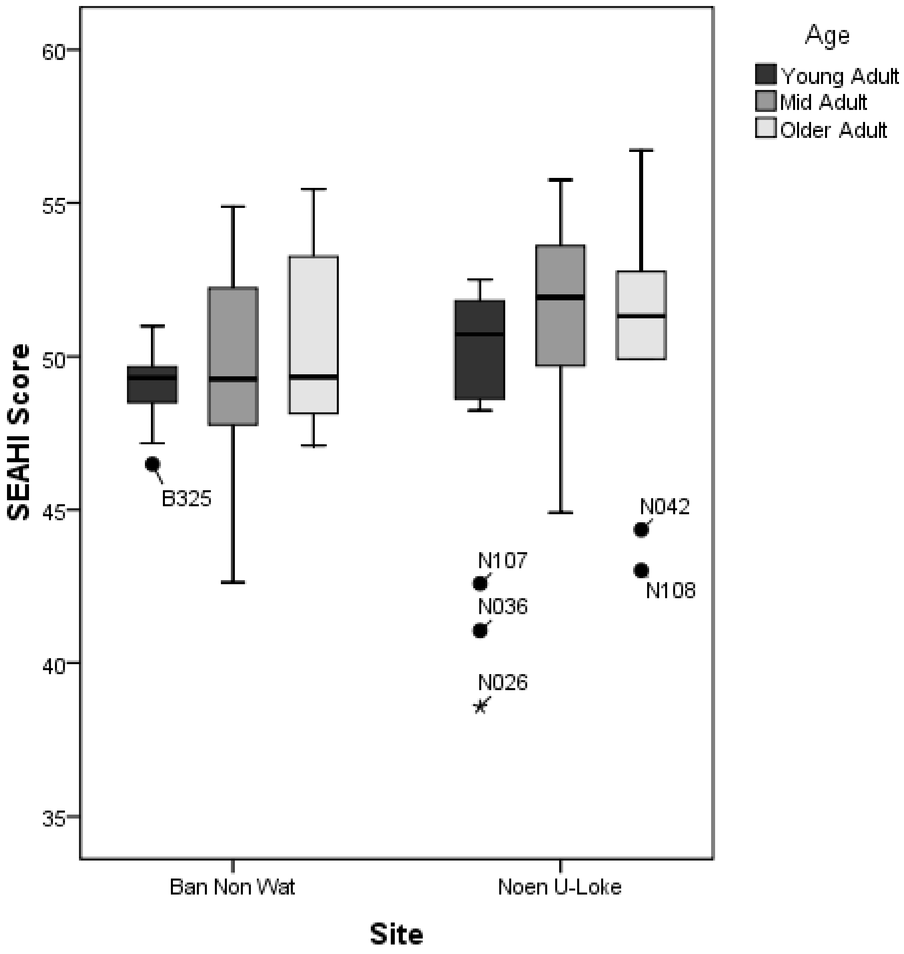

Figure 120: Boxplot of SEAHI score according to site and age.

Comparing the age groups with phases, there appears to be some differences in the age groups (Figure 121). There is a statistically significant difference amongst young adults between the phases ($\chi^2[3,\underline{N}=30]=14.017$, $p<0.05$), and mid adults between the phases ($F[3,30]=3.352$, $p<0.05$). There is a statistically significant difference between the young adults in the Early Iron and the Mid Iron Ages ($t[20] = -4.075$, $p<0.05$). In addition, Mid Bronze Age mid adults are statistically different to the Early Iron Age mid adults ($t[16]=-2.803$, $p<0.05$) and Mid Iron Age mid adults ($t[15]= -2.737$, $p<0.05$) (Table 39). There are no statistical differences between older adults in the four phases ($\chi^2[3,\underline{N}=17]=4.989$, $p>0.05$). Comparing the age groups within each phase, it was found that there was no statistical difference between age groups in the Mid Bronze Age ($F[2,10]=0.811$, $p>005$), the Late Bronze Age ($F[2,6]=0.343$, $p>0.05$) or the Mid Iron Age ($F[2,24]=1.235$, $p>0.05$). Although a one-way ANOVA did not identify a strong difference within age groups in the Early Iron Age ($F[2,29]=3.215$, $p>0.05$), a Tukeys HSD test did identify a statistical difference between young and mid adults (Table 40).

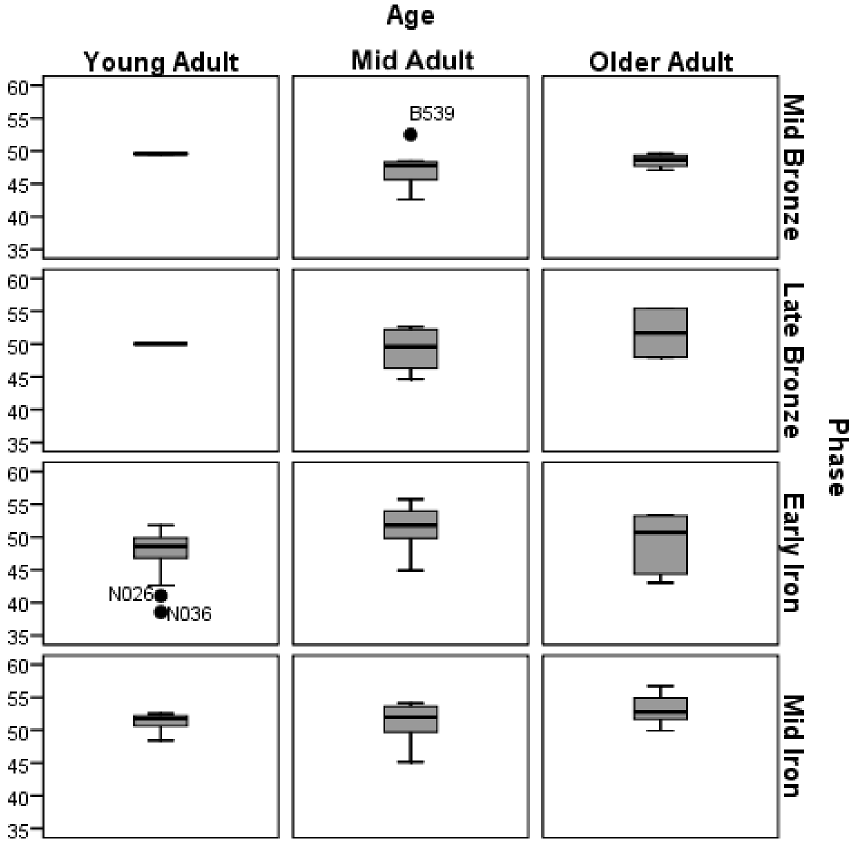

Figure 121: Boxplot of mean SEAHI score according to age and phase.

Table 39: Tukeys HSD of mid adult SEAHI score differences according to phase.

(I) PHASE	(J) PHASE	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					LOWER BOUND	UPPER BOUND
Mid Bronze	Late Bronze	-1.91437	1.71905	.684	-6.5886	2.7599
	Early Iron	-4.25319*	1.49394	*.037*	-8.3154	-.1910
	Mid Iron	-3.95749	1.52271	.065	-8.0979	.1829
Late Bronze	Mid Bronze	1.91437	1.71905	.684	-2.7599	6.5886
	Early Iron	-2.33882	1.56817	.455	-6.6029	1.9252
	Mid Iron	-2.04312	1.59560	.582	-6.3817	2.2955
Early Iron	Mid Bronze	4.25319*	1.49394	*.037*	.1910	8.3154
	Late Bronze	2.33882	1.56817	.455	-1.9252	6.6029
	Mid Iron	.29570	1.35006	.996	-3.3753	3.9667
Mid Iron	Mid Bronze	3.95749	1.52271	.065	-.1829	8.0979
	Late Bronze	2.04312	1.59560	.582	-2.2955	6.3817
	Early Iron	-.29570	1.35006	.996	-3.9667	3.3753

*. The mean difference is significant at the 0.05 level.

Table 40: Tukeys HSD test of SEAHI scores in the Early Iron Age according to age.

(I) AGE	(J) AGE	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					LOWER BOUND	UPPER BOUND
Young adult	Mid adult	-3.72030*	1.46799	.043	-7.3457	-.0949
	Older adult	-1.43285	1.78635	.705	-5.8445	2.9788
Mid adult	Young adult	3.72030*	1.46799	.043	.0949	7.3457
	Older adult	2.28745	1.87686	.452	-2.3477	6.9226
Older adult	Young adult	1.43285	1.78635	.705	-2.9788	5.8445
	Mid adult	-2.28745	1.87686	.452	-6.9226	2.3477

*. The mean difference is significant at the 0.05 level.

The mean SEAHI scores of males and females are similar (Table 41). There is no statistically significant difference between males and females (t[66]=-0.747, p>0.05). Figure 122 shows a boxplot separating the sexes into the different sites. There is also no statistical significance between males and females at Ban Non Wat (t[31]=-0.676, p>0.05) or at Noen U-Loke (t[33]=-0.534, p>0.05).

Table 41: Mean SEAHI scores according to sex.

SEX	MEAN	N	STD. DEVIATION	RANGE
Male	49.5176	35	3.51265	13.52
Female	50.1668	33	3.65869	15.66
Total	49.8327	68	3.57234	16.36

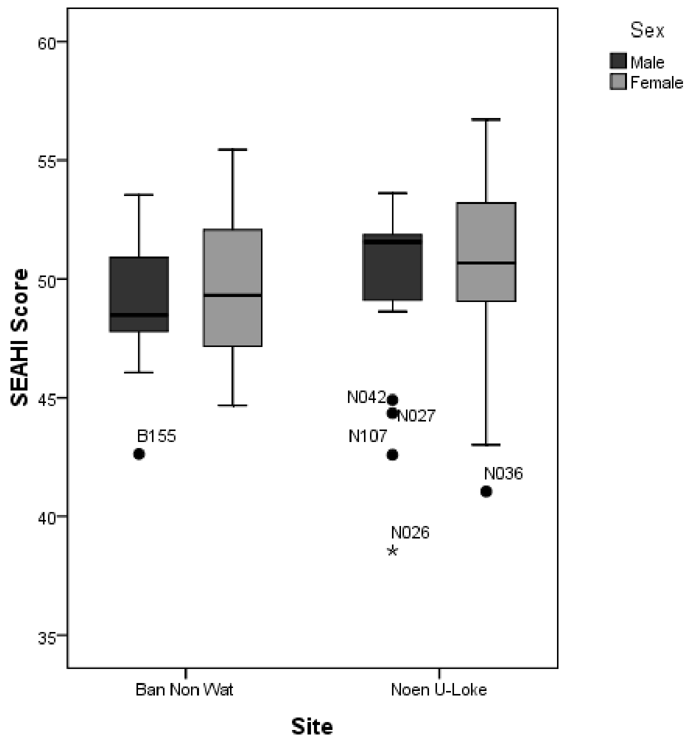

Figure 122: Boxplot of SEAHI scores according to sex and location.

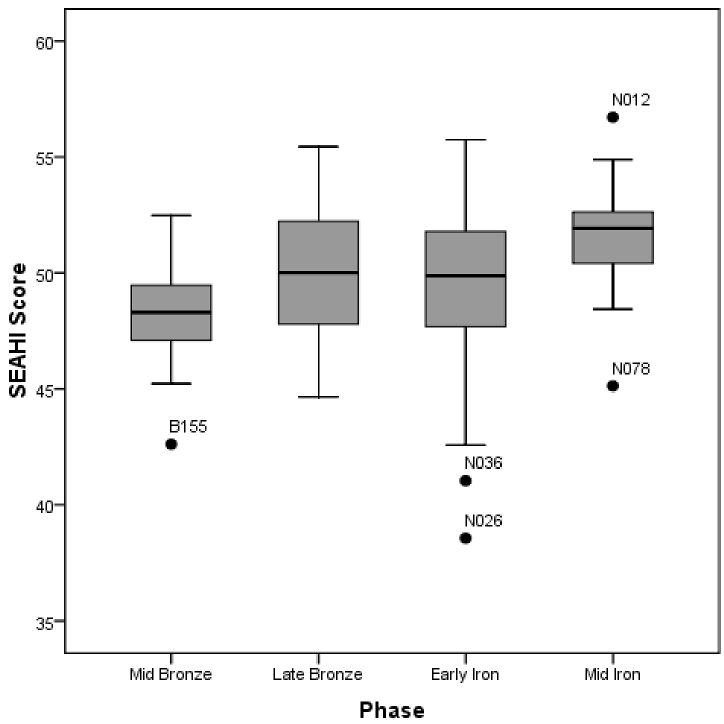

Figure 123: Boxplot of SEAHI scores according to phase.

SEAHI scores appear to improve over time (Figure 123). Statistically there is a significance difference between phases ($F[3,77]=5.682$, $p<0.05$). A Tukeys HSD test identifies the significant difference to be between the Mid Bronze Age and the Mid Iron Age as well as between the Early and Mid Iron Ages. Looking at sub-groups, a significant statistical difference between males can be found amongst the different phases ($\chi2[3,N=35]=12.862$, $p<0.05$). Males from the Early Iron Age are distinctly different from the Mid Iron Age, and the Mid Iron Age is also different from the Mid Bronze Age (Figure 124 and Table 42). There are no significantly statistical differences between females in different phases ($F[3,29]=2.247$, $p>0.05$).

Comparing the two sites in the Early Iron Age, it is evident that health was more varied in Noen U-Loke than in Ban Non Wat (Figure 125). This variation between the two sites is statistically significant ($t[23.761]=2.269$, $p<0.05$). This pattern is replicated for males and females (Figure 126). However, the difference between females at Noen U-Loke and those at Ban Non Wat is not statistically significant ($t[14]=1.095$, $p>0.05$). This result is mirrored in the comparison of males from each site ($t[10]=1.14$, $p>0.05$).

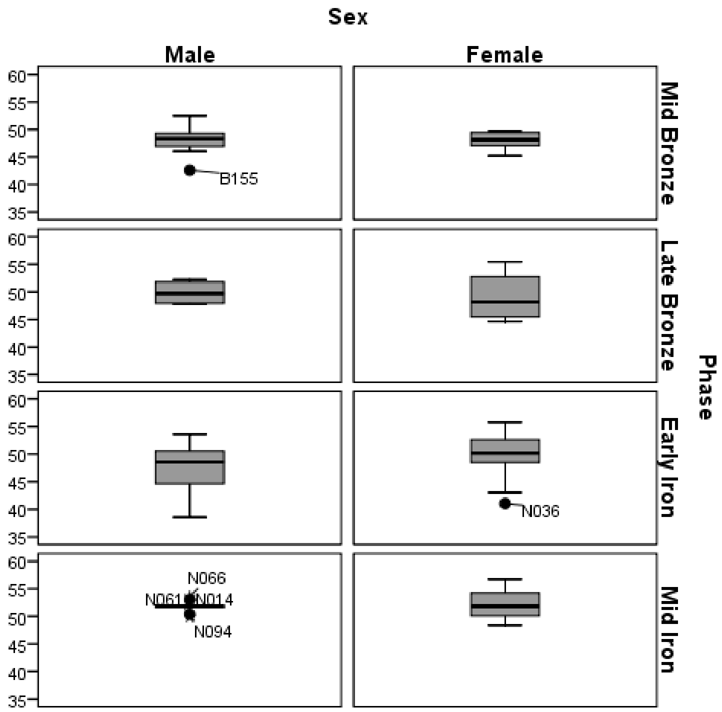

Figure 124: Boxplot of mean SEAHI scores according to sex and phase.

Table 42:Tukey HSD test of males according to phase.

(I) PHASE	(J) PHASE	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					LOWER BOUND	UPPER BOUND
Mid Bronze	Late Bronze	-1.80655	1.84722	.763	-6.8200	3.2069
	Early Iron	.22146	1.37684	.998	-3.5154	3.9583
	Mid Iron	-4.25577*	1.40165	*.024*	-8.0599	-.4516
Late Bronze	Mid Bronze	1.80655	1.84722	.763	-3.2069	6.8200
	Early Iron	2.02801	1.74158	.653	-2.6988	6.7548
	Mid Iron	-2.44922	1.76126	.515	-7.2294	2.3310
Early Iron	Mid Bronze	-.22146	1.37684	.998	-3.9583	3.5154
	Late Bronze	-2.02801	1.74158	.653	-6.7548	2.6988
	Mid Iron	-4.47723*	1.25916	*.006*	-7.8947	-1.0598
Mid Iron	Mid Bronze	4.25577*	1.40165	*.024*	.4516	8.0599
	Late Bronze	2.44922	1.76126	.515	-2.3310	7.2294
	Early Iron	4.47723*	1.25916	*.006*	1.0598	7.8947

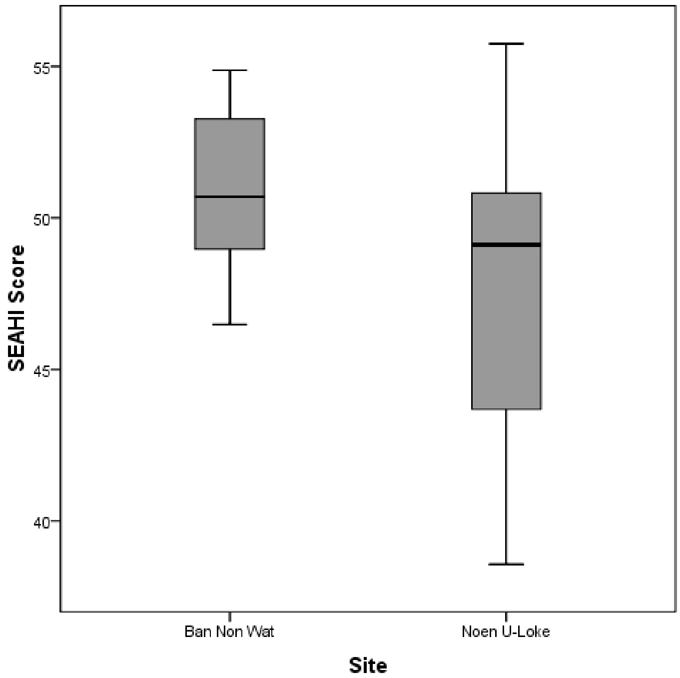

Figure 125: Comparison of SEAHI score of Ban Non Wat and Noen U-Loke in the Early Iron Age.

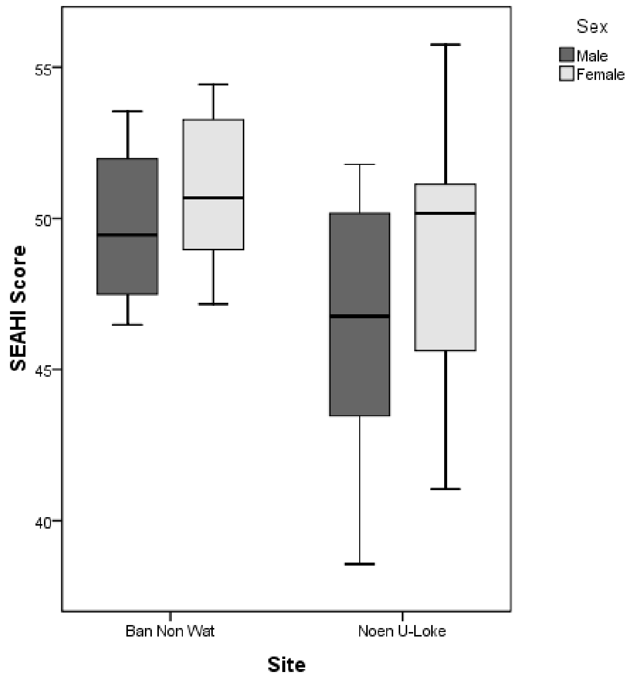

Figure 126: Boxplot of SEAHI score in the Early Iron Age by site and sex.

5.1.9 Correlation between health indicators

A correlation table was calculated using Spearman's rank-order correlation calculation. A Spearman's rank-order was used rather than a Pearson product moment correlation as some of the assumptions required for a Pearson calculation were not valid for the sample. Primarily, a Pearson product moment correlation requires an assumption of parametric assumptions. Not all individuals had all health attributes. Spearman's rank-order is a non-parametric test that does not require all of the assumptions to be met.

Following the calculation of the Spearman's rank-order correlation (Table A 27 [p. 458]), it was found that there are correlations between the following:

A. Site and Joint Disease - The correlation table shows that there is a correlation between location and the severity of joint disease. As seen in Chapter 5.1.5, there is little DJD at Noen U-Loke. This suggests that the inhabitants of Noen U-Loke had little stress on the joints, although this may be the consequence of poor joint survival.
B. Site and Pathology - There is a correlation between pathological condition severity and location. Chapter 5.1.7 shows the extent of severe pathological lesions was distinctly different according to the site. The sample from Noen U-Loke has less severe pathological indicators overall than that of Ban Non Wat. The difference was not considered to be statistically significant in a t-test.
C. Phase and Joint Disease - Joint disease correlated to time periods. This suggests that the

later the time period, the higher the joint disease score (i.e. less joint disease). The results in Chapter 5.1.5 show that the Mid Iron Age is distinctly different to the earlier phases. This result also would relate to the unusual lack of DJD in any of the Mid Iron Age samples. The Mid Iron Age only contains skeletal materials from the Noen U-Loke sample.

D. Phase and Trauma - The correlation table shows that there is a correlation between high trauma scores and the later time periods. The Mid Bronze Age sample contains the lowest scores and is specific to the Ban Non Wat sample. Previously, Chapter 5.1.2 shows that there was no significant difference between the phases in relation to trauma.
E. Phase and Pathology - Similarly to trauma, there is a correlation between high scores in pathology and later time periods. Whilst the Mid Bronze Age had the poorest trauma scores, the Late Bronze Age had the poorest pathology scores (Chapter 5.1.7). This correlation relates also to the sites and pathology correlation above.
F. Age and Joint Disease - The correlation table shows that there is a correlation between younger adults and higher joint disease scores. This correlation is to be expected in all populations. Joint disease severity is known to increase from young to older adults,
G. Age and Dental Disease - Comparable to joint disease, there is a correlation between young adults and high dental disease scores. As dentition does not heal, an increase in dental disease in older adults is to be expected.
H. Joint Disease and Trauma - The correlation that can be seen between DJD and trauma shows that those with little DJD also have little indication of trauma. This would suggest that those with little DJD, mainly young adults, did not suffer trauma or that the older a person becomes, and therefore develops DJD, the more likelihood of trauma.
I. Joint Disease and Dental Disease - There is a correlation between high joint disease scores and high dental disease scores. This correlation is also influenced by age. Those adults that are most likely to have no joint or dental disease are young adults.
J. Joint Disease and Pathology - High scores in joint disease and pathology are correlated. This also suggests that those with no joint disease, mainly the young adults also do not have pathological conditions. This suggests that they died at young age but did not suffer from chronic conditions.
K. Trauma and Pathology - A correlation can also be seen between people with high scores in trauma and pathology. This shows that individuals that do not have pathological lesions also are more likely not to have suffered trauma.

A Spearman's rank-order correlation was also calculated for each site. At Ban Non Wat there were six significant relationships (Table A 28 [p. 460]). They are:

A. Phase and Trauma - This correlation identifies a relationship between high scores in trauma through time. Each time period at Ban Non Wat shows an increase in mean trauma (i.e. less trauma) score through time (Figure 49). This may suggest at least two scenarios:

i. That there was a decrease in hard manual labour amongst the Ban Non Wat population though time and that specialised non-farming tasks became more common.
ii. Violence, intra-village and inter-village became less common in time.

B. Phase and Enamel Hypoplasia - The relationship between time and EH shows that, through time, growth disruptions that manifest as EH became less severe at Ban Non Wat. Figure 81 illustrates the pattern of EH at Ban Non Wat. The Early Iron Age is prominent in that it contains no evidence of EH at Ban Non Wat. This implies that either that survival into adulthood was dependant on not contracting any condition in childhood that caused growth disruptions, or that earlier phases had high survival of children who did suffer disruptions.
C. Age and Dental Disease - As expected there is relationship between older adults and poor dental disease scores. There is no significance beyond the pattern conforming to the norm.
D. Sex and Enamel Hypoplasia - A correlation was identified between females and higher scores in EH. As seen in Figure 77, females have a higher mean score for EH, although this is not a significant difference.
E. Joint Disease and Dental Disease - As previously identified in the overall correlation calculation for both sites, this correlation is influenced by age and therefore is not a truly significant correlation.

At Noen U-Loke, Spearman's rank-order correlation relationships were also identified (Table A 29 [p. 462]). They are:

A. Phase and Joint Disease - There is a correlation between the Mid Iron Age and high Joint Disease scores. However, as previously identified in the combined correlation calculation, poor joint survival at Noen U-Loke may have influenced this result.
B. Phase and Trauma - High trauma scores are related to the Mid Iron Age according to the correlation calculation. As with the same correlation relationship at Ban Non Wat, it can be concluded that either there was a reduction in hard manual labour across the population or that there was less violence in the village.
C. Age and Joint Disease - There is an expected correlation between old age and low scores for joint disease scores. As an individual ages, joint disease becomes more probable.
D. Age and Dental Disease - As with joint disease a correlation between an increase in age

and a decrease in dental health is to be expected.

E. Age and Enamel Hypoplasia - A correlation was found between older adults and high enamel hypoplasia scores. An examination of the scores for EH shows that young adults have a wide range of scores and have considerably poorer mean scores in comparison to older age groups. This suggests that survival beyond the age of 30 is more probable if there were no growth disruptions in childhood.
F. Joint Disease and Trauma - As mentioned previously, this correlation suggests that those with little DJD, mainly comprising young adults, did not suffer trauma before they died or, alternatively, older individuals have had a greater chance of developing DJD and also to have suffered trauma.
G. Joint Disease and Dental Disease - This correlation also appears to be highly influenced by age. Those who have little DJD also are more likely to have no dental disease. These individuals are likely to be young adults.
H. Joint Disease and Pathology - There is a correlation in high scores in joint disease and pathology. This implies that individuals lacking joint disease, mainly young adults, also have not contracted any chronic pathological conditions.
I. Trauma and Pathology - The correlation between high trauma and pathology scores suggests that if a person has not suffered any chronic pathological conditions, they also are unlikely to have undergone severe trauma. This also suggests that people with pathological conditions also suffered trauma. A complicating factor may be that the indicators of pathological conditions may also be caused by trauma.
J. Enamel Hypoplasia and Long Bone Length - There is a negative relationship between EH and long bone length in the sample at Noen U-Loke. This suggests that those with low EH scores have high long bone length scores, An examination of a scatter graph (Figure 127) shows that this relationship is not very strong, although it does show that a growth disturbance during childhood that manifests as EH may not affect long bone length, and therefore, stature.

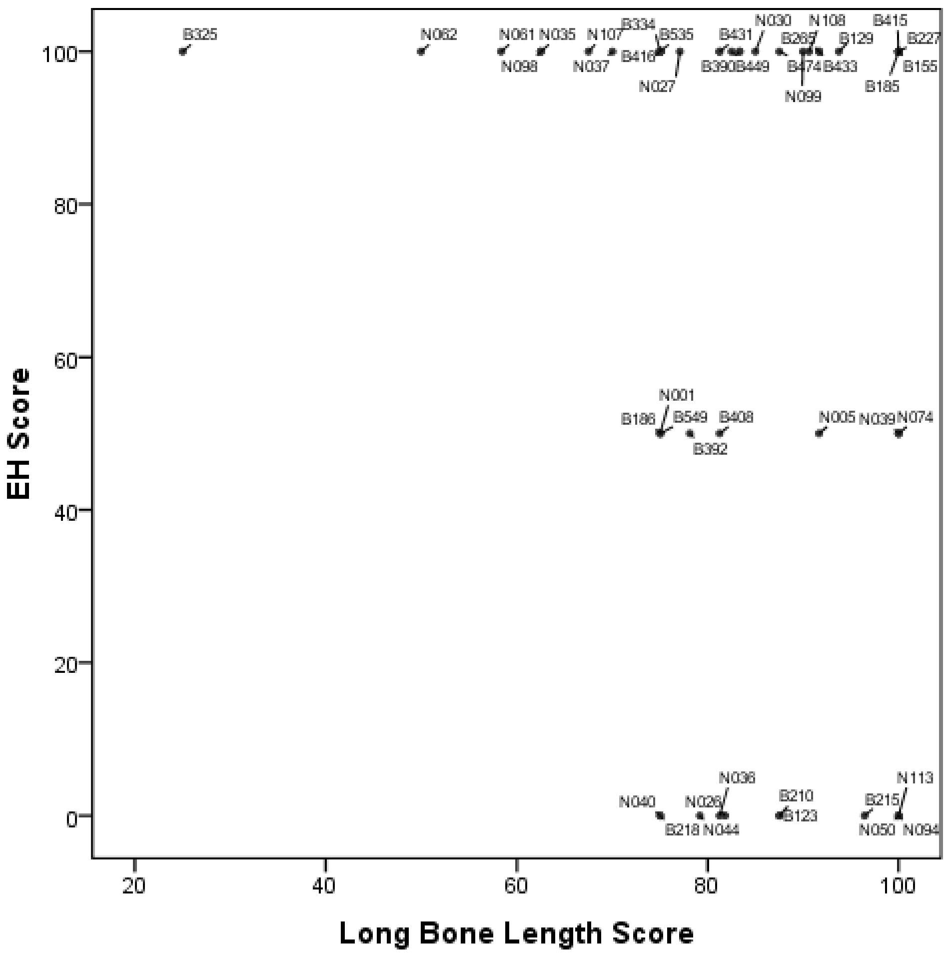

Figure 127: Scatter graph showing correlation between EH Score and Long Bone Length score at Noen U-Loke and Ban Non Wat.

5.2 Health in Ban Non Wat and Noen U-Loke

The transition from the Bronze Age to the Iron Age involves more than a simple change in the raw materials for metal objects. As discussed in Chapter 1, the Bronze Age is considered to be a decentralised society where, whilst there was rice cultivation, hunter-gathering of resources in the surrounding forests and woodlands also took place. The Iron Age sees increasingly sedentary lifestyles, specialised occupations and intensification of rice cultivation, although rice was not as dominant a component of the diet. The stressors of the Iron Age would be different to those of the previous phases. For example, rice farming using wet farming techniques provides direct contact with vectors carrying diseases that inhabit paddy fields. The level of contact with these vectors influences occurrence of disease in a population. Additionally the onset of occupational specialisation may see diversity in the prevalence and severity of joint disease. The following is a discussion of the results of the SEAHI.

5.2.1 Diet and Dental Hygiene

Diet and dental hygiene can be investigated through the SEAHI. Dental disease is found in both sites, but there is no statistical difference between them. As expected, older adults are statistically poorer in score than younger age groups. Whilst there is little difference between male and female dental scores at Ban Non Wat, there is a difference between the sexes at Noen U-Loke. It appears that females have a similar level of dental disease despite location or phase, whereas the males of Noen U-Loke appear to have improved their dental health through time.

Dental health and subsistence change in Southeast Asia has been examined by other researchers (Oxenham et al., 2006, Newton et al., 2013). Using archaeological skeletal samples from Thailand and Vietnam, caries, alveolar defects and ante-mortem tooth loss were investigated. Oxenham et al. (2006) found that there was an overall low frequency of caries and alveolar defects amongst all samples, with ante-mortem tooth loss the most common condition. There is no trend for either an improvement or decline in dental health from the mid Holocene (c 6000 - 4000 BP) to the early Bronze Age. They state that the dental health of prehistoric Asian populations is much more complicated that of the generalised view of 'agriculture equals poorer dental health'. They state that "marked social and subsistence changes generally associated with declines do not occur in Southeast Asia until the adoption of Iron" (Oxenham et al. 2006: 286). This statement is pertinent to the questions being asked in the current study. There appear to be no marked changes from the Bronze Age to the Iron Age found within the dental health of the inhabitants. Dental health does not decline and it appears to steadily improve, especially in the male population.

5.2.2 Trauma

Indicators of trauma may relate to interpersonal violence as well as to accidental incidents unrelated to warfare or fighting. There is no difference between Ban Non Wat and Noen U-Loke in relation to trauma scores. Trauma is not common in either sample, although it is most common in the Mid Bronze Age suggesting that the Mid Bronze Age was a more traumatic period relating to daily tasks or violence. Domett and Tayles (2006) investigated trauma in the Neolithic and Bronze Age periods in Thailand and concluded that the Bronze Age contained more evidence of trauma. They suggested more interpersonal violence and activity related accidents due to land clearance and the increasing development of agriculture. Although no Iron Age samples were part of the study by Domett and Tayles (2006), their results can enhance the results of the SEAHI. The Mid Bronze Age contains the highest number of individuals with trauma (38.5%), and through time the percentage of individuals with trauma declines until it is very low in the Mid Iron Age (3.7%). At Noen U-Loke alone, the Mid Iron Age period has less trauma than in the Early Iron Age. Domett and Tayles (2006) indicate that activities such as land clearance, where trees are removed in order to facilitate the cultivation of rice fields, provided the opportunity for a higher incidence of task based accidents. This hypothesis appears valid according to the results of the SEAHI, which indicates that trauma was highest in the Mid Bronze Age. This is the period when land clearance was the most intensive within the phases used in this study. As land clearance activities decline, so does the incidence of trauma.

A patterning of those with evidence of trauma can be perplexing. Lovell (1997) states that young and mid adults would suffer dislocations rather than fractures and older adults will have more fractures due to higher prevalence of osteoporotic bone at that age. At Ban Non Wat, none of the individuals that displayed indications of trauma were identified as young adults. Mid aged adults at Ban Non Wat have a higher prevalence of fractures than older adults. Overall at both sites, mid aged adults have lower trauma scores than younger and older adults. This pattern is evident in all phases except the Early Iron Age. A random examination of trauma studies that identify age groups in samples outside Southeast Asia sees a higher incidence of trauma in mid adults in some samples (Grauer and Roberts, 1996) but not in others (Andrushko, 2007). Why mid adults suffered trauma as opposed to older adults is a question that still needs to be answered.

5.2.3 Growth Disruptions

Childhood stressors are evident at Ban Non Wat and Noen U-Loke. These would have led to disruptions in childhood growth. Whilst the sample consists of only adults, the SEAHI provides an indication of what their health was like during their childhood. It also can indicate in what kind of society they were living in and if that society was capable of fostering survival into adulthood following childhood stressors. It reveals the ability of the family or village to provide for its ailing members. Ban Non Wat and Noen U-Loke have individuals with no indicators of EH as well as moderate and elevated levels of EH. This tends to suggest that nutritional stressors were not population wide but specific to individuals. Growth disruptions decrease through time at Ban Non Wat showing that childhood illnesses decreased amongst those who survived into adulthood. There is no EH in the last phase at Ban Non Wat. Physiologically, males have a higher prevalence and lower score than females. Males suffer from environmental and nutritional issues more than females (Stinson, 1985). Females appear to be able to better withstand nutritional stresses even with neglect (Zhou and Corruccini, 1998).

In Noen U-Loke, the pattern of EH in the sample suggests that survival into old age is to be expected, or more likely, if there are no growth disruptions during childhood. Young adults have a comparatively poorer EH score at Noen U-Loke. The presence of these indicators of childhood growth disruptions in young adults may suggest that survival beyond young adulthood may be subject to how healthy a childhood an individual had.

A correlation was identified in Noen U-Loke that shows that the growth disruptions that manifest as EH do not affect the stature of an individual. Stature and EH studies of a number of populations do not always identify a correlation between EH and stature, although some have identified repeated chronic stressors as influences on stature (Floyd and Littleton, 2006). In northeast Thailand, there is a correlation between stature and EH in the male population of Ban Lum Khao, where it appears male children had difficulties recovering from childhood stressors (K. Domett and N. Tayles, 2006).

In terms of long bone length, there appears to be little difference between Ban Non Wat and Noen U-Loke. Both sites are slightly above the average relative to long bone length amongst northeast Thailand sites. This indicates that there were no conditions in either location that impaired the overall population's growth or that catch up growth was possible post illness. There may be individuals that are considered smaller, but wide scale nutritional issues appear unlikely to have occurred. The only difference between the sites is that of mid aged adults. Mid adults of Noen U-Loke in the Mid Iron Age are the only large group that are below average in long bone length. In addition, males of the Early Iron Age at Ban Non Wat are well below average. These males appear to have suffered nutritional issues during childhood although none have evidence of enamel hypoplasia. The Mid Bronze Age also provides some evidence of inequality in nutrition or other stressors, seen in the significant difference in growth disturbance between males and females. It can be inferred that female children in the Mid Bronze Age received preferential nutritional and medical resources, due to their reproductive importance or that they were able to physiologically handle stressors better than male children.

Whilst it can be seen that there were some growth disturbances to individuals, the two populations were not subject to wide spread growth disruptions.

5.2.4 Mobility and Ability

Whilst it can be difficult to definitively and accurately determine the level of joint disease in a population due to the dependence on the quality of epiphyseal bone survival, the sample can be considered a representation of the population. The sample at Ban Non Wat was randomly chosen, but influenced by bone quality, whereas the Noen U-Loke sample was based on completeness and ability to record attributes. Within the Noen U-Loke sample, joint disease was recorded in 15 individuals of the sample of 43. The condition of the bone in these 15 individuals ranged from poor to good and some were fragmented. Of the remaining individuals where no joint disease was recorded, most were considered to be complete or near complete skeletons, but were mainly crushed, fragmented or in poor condition, but a few were considered to be in good condition. Based on this, and despite the poor condition of the majority of skeletons in Noen U-Loke, articular surfaces were, generally, able to be examined and, therefore, an analysis on the level of joint disease in the Noen U-Loke population can be considered to be valid.

The aetiology of degenerative joint disease is complex. Besides mechanical loads and repetitive activity, it can be influenced by hereditary factors, anatomical variance and body weight (Weiss and Jurmain, 2007). Based on the statistical analysis there are differences between Ban Non Wat and Noen U-Loke. Young adults at Ban Non Wat were mildly affected, but less so at Noen U-Loke. Assuming that biomechanical factors were the cause, this suggests that young adults at Ban Non Wat began heavy load bearing activities at a young age, causing an early manifestation of DJD. Overall, more females than males were affected by DJD. Heritability of DJD affects females especially in the hand and knee (Spector et al., 1996). The higher incidence of DJD in females may relate to genes, but environment has a strong impact on whether or not an individual develops DJD.

Modern studies on the effects of farming resulting in musculoskeletal disorders can provide a valuable insight when evaluating DJD of prehistoric agricultural populations. A study by Walker-Bone and Palmer (2002) identified patterns of DJD in modern European agricultural populations. There was a higher rate of DJD in the hip in farmers, although this result is complicated by the effects of vibratory machinery use by modern farmers. Some studies identify a higher prevalence of osteoarthritis in the glenohumeral joint in farmers (Donham and Thelin, 2006). Transporting heavy loads on the shoulder may also affect the acromoclavicular joint. The common risks that prehistoric and modern farmers include the carrying of heavy, static loads, repetitive tasks, a frequently flexed trunk and the risk of accidents. Within the Ban Non Wat and Noen U-Loke samples, the upper body was slightly more affected than the lower body and this may suggest that farming, with repetitive upper body movements and physical handling of heavy loads was the main activity causing the degeneration of joints.

There are statistical differences in joint disease scores between the different phases. A decline in DJD can be seen through time. This result is highly influenced by the Mid Iron Age scores. The Mid Iron Age sample contains individuals solely from Noen U-Loke. Very little joint disease was found in the Mid Iron Age. Those individuals in the Mid Iron Age who did not exhibit DJD were male and female and from all adult age groups. Two individuals had DJD: an older male and a mid adult of undetermined sex. The results show that, for the majority of the population in the Mid Iron Age, very little stress was placed on the joints, and therefore individuals undertook little load bearing activity, perhaps indicating a movement away from farming and towards a specialised production village, such as pottery production.

Differences are evident between the two sites in the Early Iron Age. Whilst the means between the two sites in this phase show Noen U-Loke to have less severe joint disease, the range shows a larger diversity of joint disease scores in Noen U-Loke. This may suggest that there was also a diversity of tasks or activities in Noen U-Loke compared to Ban Non Wat. Females in the Early Iron Age of Noen U-Loke are the individuals that are driving the overall pattern at Noen U-

Loke. The females at the lower end of the joint disease score may indicate that whilst there were tasks conducted by females that may not have involved heavy labour, there were females who were undertaking activities that impacted their joints, such as tilling, even amongst those who died as young adults.

5.2.5 Disease

The majority of pathological lesions found in the Ban Non Wat and Noen U-Loke populations cannot be specified to a particular disease. They are regarded as non-specific infections. Many of the pathological lesions identified in the samples may relate to traumatic periostitis. Noen U-Loke is considered healthier based on the prevalence of pathological lesions. The Late Bronze Age of Ban Non Wat contains the poorest pathology scores, especially in females, while the Early Iron Age of Ban Non Wat is distinguished by having the highest scores and indicates that the prevalence of chronic diseases declined in the Iron Age, despite increased contact with disease vectors in rice paddies. This appears to indicate that the direct interaction with these vectors did not adversely impact the inhabitants of the Iron Age as would be expected. Males generally have higher levels of pathological lesions, except in the Mid Iron Age, where there is little evidence of unspecified chronic infection. Mid adults of the Bronze Age survived chronic conditions as is evidenced in their relatively lower scores. The higher levels of chronic disease in the Bronze Age suggests that whilst there appears to be high levels of unspecified diseases, the level of health care enabled survival.

5.2.6 SEAHI

Overall the spread of SEAHI scores at each site shows that there are differences between them. Figure 128 shows the spread of scores according to site location. Noen U-Loke has the highest SEAHI score as well as the lowest. The spread of scores at Ban Non Wat show the majority of individuals to be below the norm, which is set at 50, whereas at Noen U-Loke, the majority of individuals are above the norm. The cluster of individuals at Noen U-Loke that are situated away from the main concentration have below average SEAHI scores. These individuals stand out as being the unhealthiest individuals. The patterning suggests that, overall, Noen U-Loke had a fairly healthy population, but as a result of increasing specialisation and centralisation of society, some people suffered higher levels of environmental, pathological and possibly socioeconomical stress. At Ban Non Wat, there appears to be little difference within the population to indicate any great differences between sub-groups.

Looking beyond a comparison of the two populations, there are some differences. The young adults of the Early Iron Age appear to have below average SEAHI scores. The relatively low scores are found in both sites. The Early Iron Age may have been a time of stressors for young adults that were not present in any other phase. What these stressors were is not evident. There is also an overall increase in health from the Mid Bronze to the Early Iron Age in mid adults.

This hints that perhaps socioeconomic factors for mid adults improved through time and that, overall, health was able to improve. The finding that these people did not survive until old age insinuates that any socioeconomic advantage was limited.

The healthiest person at Noen U-Loke is an older female (NUL12), whose only individual health indicator below 100 was dental health, which was only a minor deduction. This female survived until old age with little evidence of chronic disease. Perhaps her long life is due to a lack of pathological and environmental stressors. This individual may also provide an example of the females ability to buffer against environmental stressors better than males. She lived in the Mid Iron Age, a period where Noen U-Loke may have become a specialised village or a centralised society with numerous occupations. Having little evidence of stressors implies little manual labour and high levels of nutrition, hygiene and possibly high socioeconomic status.

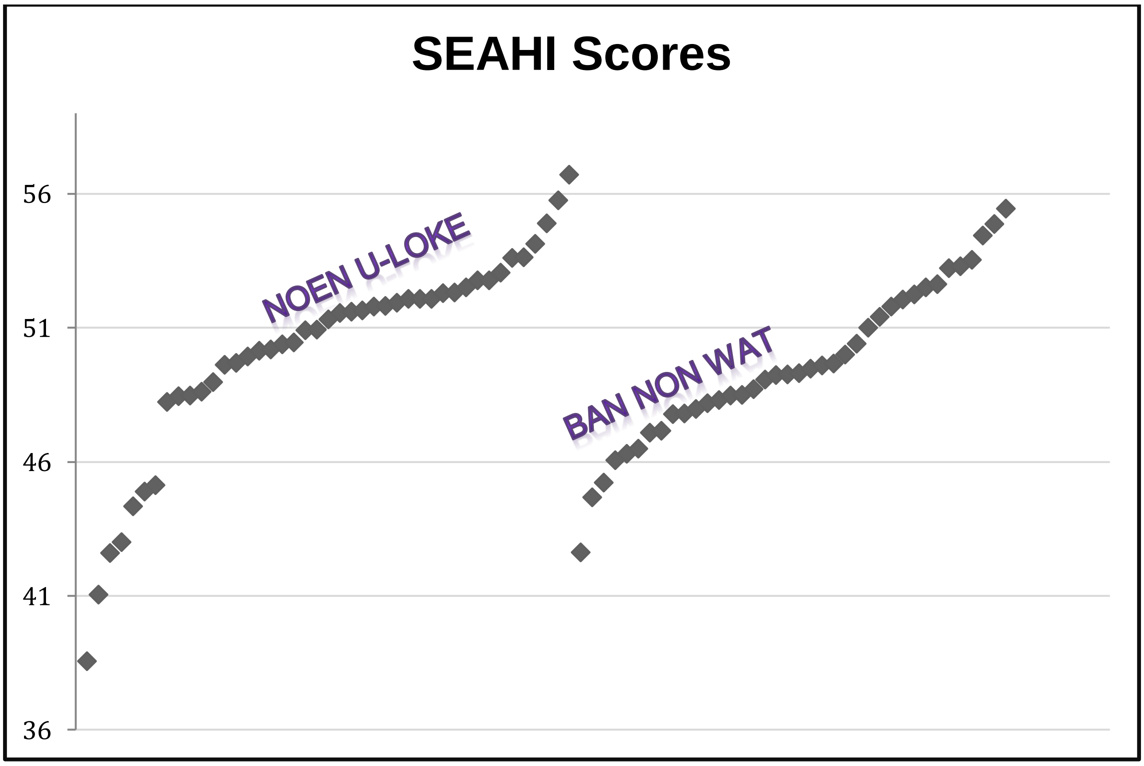

Figure 128: SEAHI scores showing score patterning according to site.

The unhealthiest person is a young adult male (NUL26) who lived in the Early Iron age of Noen U-Loke. He suffered joint and dental disease and had evidence of childhood growth disruptions and had severe pathological lesions. A differential diagnosis by Tayles et.al (2007) could not specify a condition, but propose that he may have suffered hyperthyroidism, Addison's disease or congenital adrenal hyperplasia. This young man died before he could be a fully productive and influential member of society.

All of the individuals identified as having chronic pathological conditions, such as leprosy and tuberculosis (NUL36, NUL107 and NUL42) can be found in this low scoring cluster. It should be noted that pathology comprises one eighth of the total score. This result shows that these individuals were inherently in poor health caused by more than their one chronic condition.

Within Ban Non Wat, the highest score was attained by an older female who lived in the Late Bronze Age (BNW227). She was of above average height, but had minor indications of dental and joint disease. The poorest in health in Ban Non Wat was a mid adult female, also in the Late Bronze Age (BNW218). She was of average height but had indications of joint and dental disease, severe EH and pathological lesions. This female suffered growth disruptions in childhood and chronic disease or infection as an adult. Large, active pathological lesions were identified on both femora on this individual. The stressors she suffered in childhood and as an adult appear to have lessened her ability to survive into old age.

The average score for SEAHI is artificially set at 50. Would individuals around this score represent the average health of the people of Ban Non Wat and Noen U-Loke? The individual closest to 50 is a young female from the Late Bronze Age (BNW129) with a score of 50.01. She is of average height, and has some dental and joint disease and pathological lesions. This intimates that the average life of the population in the area was short and harsh. The young participated in activities where heavy loads were carried and the diet was very gritty. Working in fields perhaps increased contact with pathogens as well as increased the chance of accidents. BNW129 had what appears to be a lesion on a lower rib, possibly due to such an accident.

The SEAHI shows that an overall examination of the health of an individual can be made in addition to the examination of sub-groups and populations. The ability to examine an individuals' life history is one of the outcomes that make this methodology valuable.

6 SOCIETY

Society is an abstract concept that generally describes a group of people living in an area with their own distinctive culture. It encompasses many aspects, such as information exchange, networks, and possibly also religious beliefs. Since the early 1800s, archaeologists have been trying to understand ancient societies based on their refuse, cemeteries and demolished settlements (Trigger, 1980, Christenson, 1989). This chapter discusses social organisation, archaeological theory and a brief overview of the use of status and wealth studies in archaeology before the specific social evidence is incorporated with the evidence for health in Ban Non Wat and Noen U-Loke.

6.1 Mortuary Practice Studies and Theory

The theories that have been developed to understand mortuary practices are complex. Many archaeologists have utilised Marxist theories to study mortuary practices over the past 30 years (Spriggs, 1984, Trigger, 1989, McGuire, 1993, Lull, 2000). This viewpoint asserts that burials are indicative of the State and social labour, seen in population economics. Lull (2000) argues that burials and any values assigned to them should be directly related to a population's economic capacity. Evolutionary theory uses Marxist and processual theories, but relies on the main premise that most people grieve more intensely when people of high reproductive value die (MacDonald, 2001).

Archaeologists contemplated what information could be gained from the dead to inform them about the contemporaneous living and from the 1970s until the 1990s there were intensive and fierce discussions regarding this topic. In general, there were two opposing views with regard to the relationship between the living and dead: processualist and post-processualists. This argument was generally restricted to archaeologists and anthropologists in the Anglo-American arena. Processual archaeologists began to look at middle range theoretical and methodological approaches that could prove that burials directly reflected society (Binford, 1971). They focused on what people did rather than asking why (Parker-Pearson, 1999). Binford (1971) claimed that human burials were complicated and variable, and in order to gain an understanding, social theory and ethnography were required. For example, Hertz (cited in Binford, 1971) argued that within a society there were visible and invisible members. Those that are invisible were children and many of the elderly people were not participants in society. He argued that mortuary rituals were related to the level of participation an individual had in a society.

Expanding on the social theory concept, Binford (1971) stated that variability in mortuary practices is related to the environment, the exchange of ideas, and the relationship of the individual to the society as a whole. Binford (1971: 25) stresses the need to understand the "organizational properties of cultural systems" prior to trying to understand burial customs. Following a survey of ethnographic literature, he found that burial custom depended on age and sex of the individual, their relative social status and social affiliation as well as the circumstances of death.

Saxe (1971), a fellow processualist, firmly believed that treatment in death reflects social status. One of Saxe's hypotheses is that low status burials should have fewer burial goods and less variation between burials (Parker-Pearson, 1999). In addition, Saxe (1971) argues that cemeteries are only found in societies where social groups used burial rites in order to justify their power and access to resources and land, on the basis of ancestor descent. This argument anticipates elements of the post-processualist approach in that it does not simply equate burials with status.

The processualist view provided a much needed impetus to re-examine social status and society in archaeology and one of the most positive aspects was that it reinvigorated investigations into burial archaeology. However, many archaeologists rejected the processualist viewpoint. Hodder (1991) believed a return to a similar system previously used by Childe; that of culture-history and symbolism, was required. As a result, he encouraged what came to be known as post-processual thought. A wider range of theories was utilised, especially from Europe, such as NeoMarxism and structuralism. Post-processualists investigated mortuary contexts from numerous aspects, not only looking at functions of goods, but also through the expressions of ideas, as manifested in the burial goods. These ideas include ideological expressions of power, as well as manipulation and misrepresentation of ideology for personal gain (Shanks and Tilley, 1982, Parker-Pearson, 1999). This suggests that mortuary practices are dynamic and malleable social constructs.

Neither viewpoint is thought to adequately address the problems in interpreting mortuary goods, but a combination of both can assist in providing a basis for a valuable interpretation (Shimada et al., 2004). This incorporation of elements of processual and post-processual thoughts has been called 'Processual Plus' (Hegmon, 2003). It is "not a single, unified theory: rather, it is a perspective that generally accepts processual goals of developing testable and sometimes generalizable approaches and explanations, but that also is open to postprocessual interests such as symbols, gender, practice, and interpretation" (Hegmon, 2005: 589). It would be true to say that most archaeological research today can firmly sit within Processual Plus, where science, function and symbolism meet in a compromise.

Specific theories have been postulated regarding why societies change. The causes of socio-cultural change have been identified as environmental stressors; emergence of self; or as a result of a prime mover (Gibbon, 1984). A prime mover is as it suggests, that there was one main source of socio-cultural change, such as population pressure. Whilst the 'emergence of self' theory relates mainly to early anatomically modern humans, it can also be used as a theory of socio-cultural change in the Bronze Age/Iron Age of Southeast Asia. Solomon et al. (2008:21-22) states that self-consciousness allows people to have "the abilities to actively reflect on the past, to consider the possible consequences of a host of future potential courses of action, and to imagine novel possibilities that are then enacted in reality surely enhance inclusive fitness not only by allowing people to engage in a wide variety of actions in response to environmental conditions but also by allowing them to render environments suitable for their needs". This self-consciousness would also acknowledge mortality and it would impact on future acts of the individual or group.

Terror management theory relates to how humans deal with their mortality: "the explicit awareness of death as a natural and inevitable event, an awareness that threatened to undermine consciousness, intellectually and emotionally, as a viable form of mental organization" (Solomon et al., 2008:28). Death is one of the most frightening threats for humans. Solomon et al.(2008) propose that the transition from a hunter-gathering lifestyle to an agricultural lifestyle was related to an "evolutionary change" in how humans thought, especially about death. That people with common beliefs gathered together, was, in turn, aided the ability to 'manage' the terror of death. With these gatherings, the population became self-aware that their future lay in agriculture and that hunting resources were no longer easily obtainable; therefore, collectively, society changed to embrace this awareness. This change is then reflected in the funerary treatments, as they abandoned hunting and foraging to adopt agriculture fully.

6.2 Status and Wealth – a misnomer

Status in archaeological contexts generally refers to the status of an individual within a society. Social status incorporates a number of dynamic factors, including prestige relating to family connections, income and occupation. There have been numerous methods or theories for assessing the status, mainly by identifying the 'wealth' of an individual burial. These are discussed briefly below in relation to their value to this study.

6.2.1 Production, energy expenditure and investment

Investment in manufacture of burial goods and the container in which the body was buried is one method of estimating wealth (Shimada et al., 2004). Status has been investigated by looking at material type and time invested in making the burial goods. For example, bronze is considered to be a material in which there is a high amount of time invested in order to make an object from it. It has to be procured, dug out of the ground, possibly imported, then, it would have to be worked in order to make goods, such as jewellery. Tainter (1978) looked at the correlation between mortuary treatment and social status by the energy expended in the treatment. It is, however, difficult to calculate the energy expended, and also to know exactly what is being measured (Shimada et al., 2004). A part of this energy expenditure method involves grave cut size (O'Reilly, 2001). The bigger the cut, the higher the status of the individual. This methodology can be difficult to determine and test where grave cuts are indistinct and does not take into account the function or context of the goods (Hodder, 1991) .

6.2.2 Production steps

The steps used in ceramic production have been used to designate wealth. This method calculates the production steps required in order to make a ceramic vessel. One point equates to one step in the manufacturing process. This method does not account for more time-consuming steps and the circumstances behind the production of the ceramic (O'Reilly, 1999). Additionally, it does not account for the clay source and importation of goods. This measure is generally not used at an individual level, but at a site by site level. It appears to be more of a test of change in technology, rather than status.

6.2.3 Rarity of artefacts

Rarity of artefacts found in burials has also been used to indicate wealth. The assumption being that rarity equates with status. In order to understand social stratification, Alekshin (1983) suggests that for each group a normal or standard assemblage of grave goods be produced by a researcher as a baseline. How a researcher establishes the standard is not explained by Alekshin. This would have to be an arbitrary designation with numerous potential biases. To place individuals on a comparative scale, Alekshin (1983) suggests that one type of good, such as metal objects be used. The calculation would involve the number of metal objects in a grave; the material of each object; and the type; for example, weapon, tool or utensil. Burials with unique goods made from certain ‘higher value’ metals would be considered to be wealthier than others. To use such a methodology as this, an understanding of the value of each metal object would be required. This would include obtaining information with regard to procurement, ease of use and trade networks. Obtaining such detailed information is more specialized and beyond this topic.

6.2.4 Quantity of grave goods

The quantity of grave goods relative to other graves has commonly been used to identify status. This simple method avoids placing any symbolic or economic value on objects. This method is inherently lacking in contextual information and may be considered too simple and unsophisticated, but does provide a comparative framework that does not involve interpretive biases. In his study of sites in Thailand, O’Reilly (1999) identified the social status of individuals by calculating the sum of the artefacts in each burial; one artefact equals one point. This method, however, can only be used to compare individuals who were buried in similar time periods. The rites at burial rituals, which may vary through time, are not taken into account.

This method assumes burial ritual is static.

6.2.5 Symbolism

Symbolism has also been used to identify status (Peebles, 1971). Peebles was of the opinion that those treated differently in life would also be treated differently in death. Status would be implied within the burial by a certain 'class' of goods, considered to be symbolic, as well as the orientation of the body and mortuary treatment. Peebles looked at the prehistoric AmerIndian burials found at Moundville and other sites in the region. Symbolic goods or burial attributes were identified and frequencies calculated at each site. These symbolic items and features included ceremonial flints, stone discs, the eagle symbol, and ritual death of an infant or placement of a ritual skull. Moundville was identified as being distinctly different from the other sites in the region as this was the only site that contained numerous symbolic items attributable to high status. Peebles concluded that Moundville was part of a complex, ranked society, whereas outlying sites were subordinate satellites.

The social organisation of populations in Neolithic China has been investigated in relation to the presence of pigs in burials (Kim, 1994, Lee, 1994). Pigs are the most common domesticated animal found in Neolithic burials in China. Kim (1994) wanted to test the theory that pigs, as symbols, were used by the social elite to build and establish power and found that, overall, individuals buried with pig skulls had markedly more burial goods. Lee (1994) commented on Kim's study, stating that the burials without pig skulls were also variable in wealth; therefore, pig skulls in graves should not be taken as a given to indicate wealth. As symbolic value is difficult to determine, this method is unsuitable for the current study.

6.2.6 Wealth Indices

Construction of a wealth index has been used by some archaeologists to enumerate wealth by differentiating between prestige and domestic goods. These wealth indices have not been employed, generally, for burial contexts. Turkon (2004) devised a system of prestige good and domestic good indices for Pre-Hispanic Mesoamerican kitchen midden sites. The prestige goods indices included the following categories: decorated ceramics; diversity of ceramics; amount of labour required; and non-ceramic prestige goods, such as stone and obsidian. Domestic indices included maize, taxa diversity, ground stone and serving vessels. The combined 'Prestige' indices were then compared to the combined 'Domestic' indices and cluster analysis identified three groups; identified as low, intermediate or high status. This type of status study is multi-disciplinary, as it utilises macro botanical data found at sites. Serving ware versus domestic ware as a measure of status has been used elsewhere, such as at the Moundville site (Welch and Scarry, 1995). Value judgments are placed on goods, such as the designation of serving vessels. The labelling of goods as either prestige or domestic needs careful consideration.

6.2.7 Unravelling the past by probing the grave: Can wealth or status be identified?

> "To start with the presumption that cemeteries/graves with fewer artefacts necessarily represent poorer and/or lower rank communities/individuals than more elaborately furnished cemeteries/graves, rather than possibly representing distinctive burial rites related to cultural factors is to make an unjustifiable jump from the empirical data to the social organization." (Pader 1982 cited in Goring, 1989: 97).

There have been many methods, from simple to complex, of assigning status. Many researchers believe that wealth or status can be inferred from archaeological contexts (Rupp, 1989). Burial goods are not necessarily an accurate reflection of the life of the deceased. The actual interment is only one part of funerary ritual. Other aspects, in the wider community, may impact on the burial itself. Unfortunately, there are no archaeological theories or methods that can explain the wider context of funerary ritual. The reasons for elaborate or simple burials are wide and varied.

There are numerous issues in the identification and labelling of 'types' of societies. A modern example of this was identified by Todd (1974 in Gibbon, 1984). The house and possessions of the head man of an Anatolian village in modern rural Turkey were compared with those of other villagers and found to be similar. Therefore, absence of 'wealth' does not necessarily make an egalitarian society.

The symbolic and ritual nature of goods found in burial contexts is inherently difficult to interpret. Modern ethnographies have been valuable in many archaeological studies by helping interpret archaeological data. Brown (1971) looked at the ethnographic information on the burial rites and procedures of a number of AmerIndian tribal groups and used this to understand an archaeological site dating to the 1400s. In Southeast Asia there is no such ethnographic data available for use in interpretation of archaeological data. If there is no reliable ethnographic data about the population under study, then any interpretation of the social organisation may be invalid (Gamble et al., 2001).

Understanding the past can be difficult, as archaeologists of today inevitably utilise what is familiar and connect aspects of the present with the past (Thomas, 2004). This problem is associated with site interpretation and was clearly illustrated in the early 1970s (Bonnichsen, 1973). Bonnichsen conducted an archaeological investigation of a recently abandoned campsite in Canada, interpreting features and activities. Then the former inhabitants were brought back to see if the data was interpreted correctly. Bonnichsen found that items were misidentified, and associations between items misinterpreted, as were activity areas and relationships between activity areas. Archaeologists are not familiar with the past population activities and the material evidence that they leave, and there is a tendency for archaeologists to superimpose their own knowledge onto archaeological contexts.

How does an archaeologist know if the burial goods actually belonged to the deceased or even represent their wealth? Brown (1999 cited in Gamble et al., 2001) translated ethno-historic texts on the Chumash Indian tribal group in the United States. At a particular funeral in the 1700s, he describes the attendants cutting off their own beads and then adorning the deceased with them. For the same group, belongings owned by the deceased were burned at a later memorial event (Harrington cited in Gamble et al., 2001). This example reflects the difficulties in interpreting ownership. Goring (1989: 104) writes, in relation to burial goods in Late Bronze Age burials in Cyprus, that “the social organization of the group to which the occupants of the tomb belonged evidently required, or at least enabled, the deposition of substantial amounts of artefacts”. Goring further explains that the reason for each particular artefact being deposited cannot be explained, neither can we know whether or not they were personal effects of the deceased. Complications may include emotional investment, projected adult social status of a child, and withholding of goods for future memorial ceremonies.

Rupp (1989: 353) recognizes the complexities of inferring status from burial goods, and states that an understanding of the “geographical findspot”, the context, associated artefacts, the “Manner and purpose of deposition”, date and “Spatial and chronological patterning of the artefact type” is the minimum requirement for interpretation:

One of these requirements is unlikely to ever be known in prehistoric archaeological sites, that is manner and purpose of deposition. This information can only be gained for historical sites, through ethnographic information and participant dialogue. Can we then conclude that status inferences are not possible?

Status interpretations are related to an individual’s level of wealth, as well as at a population level to see what type of society the individuals lived in (Gamble et al., 2001). In more modern times, complex ‘status’ identification in archaeological studies is commonly attempted, especially in highly ranked or State societies (Pearson et al., 1989). A common archaeological site type is the cemetery. Although the estimation of wealth using burial goods is contentious (Alekshin, 1983), most wealth estimates have utilised burial goods data, whilst some have used domestic data from occupational deposits (for eg. Turkon, 2004). Ranking methodologies have also been used to identify the social status of individuals using data from burial goods and treatment. These studies have been based on what have been termed ‘status’ determinations. These methodologies are inadequate and this study aims to find alternative ways of looking at society.

6.3 Burial Treatment

The goods that are placed in the grave of the deceased are considered to be indicative of the loss of that person by family and friends and of the disruption to the community. It signifies the character of social relationships, identified in the social identity, of that person (Brück, 2004). Many grave goods are symbolic of the emotional link between the living and the dead. Items of jewellery, for example, may not have been owned by the deceased, but were placed there by a mourner. Items that may suggest the occupation of the deceased, such as the spindle whorls of a textile worker, may not be directly indicative. Bruck (2004) argues that it may have been the mourner who was the textile worker and not the deceased. In the past, archaeologists have assigned identity to the dead with labels, such as 'rich', or 'warrior', based on the presence of burial goods. This is more a reflection of modern Western ideals than actual assessment of past society.

There are no methods that can unequivocally determine whether or not the burial goods belonged to the deceased or the social value, or wealth, of those goods. There are a number of approaches used in this study, which is inspired by the study by Robb et al. (2001). The first is designed to be simple, so as to minimise the influence of modern preconceptions. Burial goods are placed into larger groupings. Whilst every effort is made to avoid modern preconceptions, some assumptions are made, for example, an implement is judged to be 'industrial' based on what I define as 'industrial.' Essentially, I have made the judgement that the item cannot be 'ornamental' by designating an object 'industrial'. The second approach encompasses a number of diverse factors and methods, for example by examining burial orientation, number of artefact types, etc. as well as identifying any correlations between the different factors. This approach is included in this study for the purpose of identifying any burial ritual patterns as well as to test their ability to inform on social identity.

By testing the different methods, however, value judgments are inevitably placed within the analysis. It is hoped that by providing simple and independent approaches, an aim of the study to identify any chronological patterns that can convey information on ritual burial behaviours can be achieved.

Social identity theory is at the heart of this analysis. In essence, this theory describes how an individual's association with groups has a role in the formation of an individual's identity (Stets and Burke, 2000). This is the realm of the perceived identity. This study is in effect trying to understand the perceived identity as seen in the death ritual. Whilst it is difficult to recognise an individual's identity archaeologically, some aspects that may be ascertained are age, sex, possibly gender, ethnicity, location, and possibly occupation and economic status. As stated earlier, there may be differences in the death ritual when there are periods of societal instability or stability, identified as social competition (Kamp, 1998). By looking at patterns through time, social competition factors may be identified. In order to do this, we also have to ask questions on the validity of the analysis. Can we see if there are differences between the Bronze and Iron Age in burial ritual? Can we compare a Mid Bronze Age burial with an Early Iron Age burial if the rituals involved were different?

6.3.1 Burial Goods Types - Groupings

The present study endeavours to identify patterns and relationships relating to burial goods in a way that is more objective than subjective. The first approach relates to the classification of burial good types at Ban Non Wat and Noen U-Loke. This approach was based on Robb et al. (2001). Some previous grave good studies have subjectively determined symbolism from burial goods or attempted an objective evaluation based on rarity or quantity of artefacts. The aim of this study is that no value judgement, defined by ‘wealth’ or ‘richness’ is placed on any of the goods. The burial goods found in each of the graves have been classified according to a simple typology. There are six burial good types: ‘ornament’, ‘pottery’, ‘animal bone’, ‘blade’, ‘industry’ and ‘other’. These comprise the following:

- Ornaments – This includes objects of decoration, such as jewellery and personal ornament. These are made from clay, ivory, stone, and shell including rings, necklaces, belt, bangles, pendants and ear plugs. This burial goods type may be indicative of the individual’s perceived social identity.
- Blade – This burial goods type includes all sharp implements. The justification for combining all sharp implements into the one burial goods type is that it is difficult to associate a specific activity with a sharp implement. For example, a spear head may have been used in warfare, but also in hunting animals; a blade may have also been used in warfare, but also in the fields and domestically in the home. This burial goods type may be indicative of activity, but not specifically.
- Pottery – all of the pottery vessels found in graves associated with individual skeletons are included in this burial good type. The presence of this burial goods type may indicate the individual’s perceived social identity.
- Animal Bone – All types of unmodified animal bone are part of this burial good type. All modified bones are placed in their appropriate group, for example, a tooth pendant is placed in the Ornament burial good type. This burial good type may be indicative of activity; for example, wild animal bones may be placed in the grave of a hunter; or it may relate to ritual or religious aspects, for example, if families had animal totems ot moieties. When identifying numbers of animal bones, a Minimum Number of Individuals (MNI) approach is adopted. For example there may be a fish skeleton,

which counts as one individual. Similarly if there are two pig's trotters, a left and right, these are also counted as one individual.

- Industries – All goods that are considered production tools for any industry, such as pottery or textile manufacturing, or for any other form of fabrication of goods have been grouped here. These may include spindle whorls, pottery anvils and rollers, and clay moulds. This burial goods type may be indicative of activity. The products that these implements were used for making are not necessarily indicative of activity.
- Other – in this category of burial goods, all other objects that cannot be placed into the above groups are placed here. Items may include ochre, rice, or unidentifiable metal objects. This burial good type may be potentially significant in terms of the individual's perceived social identity.

6.3.2 Other Factors

Previous studies have attempted to place a ranking or scoring system on burial goods, such as those studies that employ wealth indices, energy expenditure or production steps methods (Tainter, 1978, Alekshin, 1983, Turkon, 2004). The second approach in this study which is applied at Ban Non Wat and Noen U-Loke utilises some of the elements of wealth indices used in some previous studies, as they have multiple factors, and involves the assessment of various incongruent elements that are used in order to identify patterns. These ritualistic factors, that do not involve burial goods types alone as seen in the first approach above, include:

- Grave size
- Orientation of the body
- Position within cemetery
- Supine/Prone or Flexed/Extended positioning
- Method of burial (coffin, wrapped in cloth, bark etc…)
- Presence/absence of ornamental pottery

Whilst these factors are valid, not all can be used in this study for a number of reasons. Firstly, some data, such as grave size and method of burial, may not be available. Soil chemistry influences the survival of burial containers and all evidence of them may vanish. The outlines of graves are difficult to distinguish in many soils and; therefore, grouping by grave size would not be appropriate in this study. Unless all of the burials within a cemetery are excavated, then the position within the cemetery grouping is invalid. Orientation and Supine/Prone and Flexed/Extended positioning, however, can be identified for most and could be used in this study. The positioning of the body needs to be recorded for each burial to be able to be used in this study. The use of ornamental pottery is subjective. What defines whether or not pottery is ornamental or made for domestic orutilitarian use needs to be clear. As there has been no analysis on the pottery of Noen U-Loke, this category cannot be used.

Other burial goods factors can be used to look at patterning. The inclusion of these aspects was inspired by the study by Robb et al.(2001). They include methods that impart value judgements on burial goods as well as quantification methods. They are:

- Number of artefacts. A simple comparison of individuals based on the number of artefacts they have. This method associates superior status with higher numbers of artefacts. Although I believe this method to be flawed, it will be tested as a comparative method.
- Number of ornaments. This method differentiates individuals based on the number of ornaments they have buried with them. This method weighs status according to the amount of ornaments. Again, although this method appears flawed, it will be tested.
- Presence of wild animal burial goods. This method attempts to identify burial ritual differences between burials with wild animal goods and those without. This may assist to identify the significance of the wild animal objects.
- Exotic goods. Within any sample, there are goods that are uncommon. If these can be identified and then a comparative analysis produced for presence/absence of these goods, then the significance of these goods may be able to be estimated.

6.3.3 Recording Burial Goods Data - Noen U-Loke

The analysis of artefacts found at Noen U-Loke had been completed prior to this study. The burial goods were examined and analysed by various researchers and the results of their work have been published in the Noen U-Loke report (Higham et al., 2007). From this report burial goods have been collated for each individual in this study. Comprehensive information was available on personal ornamentation and metal goods. Where detailed information was lacking in the Noen U-Loke report, especially in relation to pottery goods, photographs of each burial were used to identify goods. These photographs, which include identified artefacts and catalogue numbers, were contained within the report.

6.3.4 Recording Burial Goods Data - Ban Non Wat

The artefacts found in association with skeletal remains have not yet been examined in detail by researchers during the data collection period for this study. The list of burial goods generated for this study was obtained by examining the field burial register, where burial goods are noted and assigned catalogue numbers, field drawings of individual burials and the 2005/6 field season photographic record (Higham, 2006). Many artefacts may be missing from this list, especially those that are still attached to skeletons that have yet to be fully cleaned. Some personal ornaments, for example, were found when the soil on the human remains was cleaned prior to analysis. Whilst this is an imperfect situation, as the burial goods list is preliminary at best, it is likely to include the majority of artefacts with which an individual was associated with.

7 BURIAL TREATMENT RESULTS

7.1 Noen U-Loke and Ban Non Wat

The following sub-chapters detail the results of the burial goods assessment and provides direct comparisons between sites. As noted previously, the Ban Non Wat representatives are only a subset of a much larger sample. The purpose of this is to provide an example of the methodology, not an all-encompassing burial goods analysis of the Ban Non Wat interments. As with any study, the larger the sample the more accurate the conclusions regarding the lifestyles of the inhabitants. For this study, age, sex, phase and location are the contextual parameters that this burial goods study will use.

7.1.1 Ornaments

Within Noen U-Loke, 90.7% of burials in the sample were buried with ornaments. In the Early Iron Age 87.5% of burials have ornaments and in the Mid Iron Age 92.6% have ornaments. This high level of ornaments in the burial ritual is not seen in Ban Non Wat. At Ban Non Wat there appears to be a distinct difference between the Bronze Age and the Iron Age in relation to the absence or presence of ornaments. Table 43 shows a reversal in the trend in the presence/absence of ornaments from the Bronze to the Iron Age. The Iron Age of Ban Non Wat is exceptional in that over 80% of the Iron Age sample was *not* buried with ornaments. At Noen U-Loke, during the same time period, over 85% were interred with ornaments.

When the data from Ban Non Wat and Noen U-Loke are combined, there is a statistical correlation between the presence of ornaments and phase (Table A 30 [p. 464]), that is the higher amount of ornaments are found in the later periods. This is confirmed in a Pearson Chi-Square Test (χ^2 (3, N=81) =11.026, $p<0.05$). The cross tabulation of these two variables shows that the Mid Iron Age is significant in that inhabitants are more likely to have been customarily buried with ornaments (92.6% of Mid Iron Age sample have ornaments) (Table 44).

Table 43: Percentage of burials at Ban Non Wat according to presence of ornaments.

	MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
Absence	30.8%	33.3%	81.3%	52.6%
Presence	69.2%	66.7%	18.8%	47.4%

Table 44: Cross tabulation of presence/absence of ornaments and phase in Ban Non Wat and Noen U-Loke.

			PHASE				TOTAL
			MID BRONZE	LATE BRONZE	EARLY IRON	MID IRON	
Ornament	No Ornaments	Count	4	3	15	2	24
		Expected Count	3.9	2.7	9.5	8.0	24.0
		% within Ornament	16.7%	12.5%	62.5%	8.3%	100.0%
		% within Phase	**30.8%**	**33.3%**	**46.9%**	**7.4%**	29.6%
		% of Total	4.9%	3.7%	18.5%	2.5%	29.6%
	With Ornaments	Count	9	6	17	25	57
		Expected Count	9.1	6.3	22.5	19.0	57.0
		% within Ornament	15.8%	10.5%	29.8%	43.9%	100.0%
		% within Phase	**69.2%**	**66.7%**	**53.1%**	**92.6%**	70.4%
		% of Total	11.1%	7.4%	21.0%	30.9%	70.4%
Total		Count	13	9	32	27	81
		Expected Count	13.0	9.0	32.0	27.0	81.0
		% within Ornament	16.0%	11.1%	39.5%	33.3%	100.0%
		% within Phase	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	16.0%	11.1%	39.5%	33.3%	100.0%

Table 45 identifies the presence of ornaments in a grave according to sex at each site. At Noen U-Loke, all of the females (n=16) had ornaments interred with them, and males also had a high percentage. At Ban Non Wat, approximately half of the females and half of the males were interred with ornaments. More informative is the division of the sexes according to time period (Table 46). The percentage of males and females at Ban Non Wat with personal ornaments declines through time. In both Bronze Age periods, female burials dominated the burials with ornaments, yet in the Early Iron Age, there is a sharp decrease in ornaments for both sexes, and males have a higher percentage of individuals with ornaments. Noen U-Loke has a high level of ornament burial ritual in both Iron Age periods for both sexes.

Table 45: Percentage of individuals by sex according to presence of ornaments interred in burial.

	MALES	FEMALES
Combined sites	65.7%	72.7%
Ban Non Wat	50%	47.1%
Noen U-Loke	78.9%	100%

Table 46: Percentage of individuals by sex and site through the time phases according to presence of ornaments.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Males	62.5%	50%	58.3%	25%	75%	81.8%
Female	80%	75%	56.3%	12.5%	100%	100%

The percentage of individuals at Noen U-Loke that have ornaments according to age are, as expected, high (Table 47). All older adults have ornaments and, the percentage gradually lowers to 86% of young adults. This partially shows that age has some part to play in whether or not ornaments are part of the burial ritual. This pattern is also seen in Ban Non Wat, where young adults are unlikely to have been buried with ornaments. Again, when the time periods are examined, more informative indications regarding burial ritual are provided (Table 48). Although the number of young adults at Ban Non Wat in the Bronze Age (n=3) is small, we can suggest that in the Mid Bronze Age, age was a major factor in whether or not ornaments were placed in the grave. Older adults and mid adults were more likely to be buried with ornaments. The Late Bronze Age sees an increase in ornaments in the burial ritual, seemingly unrelated to age. The Iron Age of Ban Non Wat, however, sees the mid aged adults as the main recipients of ornaments in the burial ritual. This suggests that social identity, and how much that person is valued as a working member of society and the loss of that value is reflected in the placement of ornaments in the grave. This pattern is not reflected at Noen U-Loke, where age still appears to be the more important factor.

The Early Iron Age is the only period when the two sites can be directly compared. As there is a definitive difference in ornament use in the burial ritual between the two sites, a breakdown of those individuals with ornaments was undertaken. Figure 129 shows that of the few individuals in Ban Non Wat that had ornaments, mid adult males and mid adult females were the only ones with ornaments. These individuals with ornaments make up only 30% of the mid adult sample from the Early Iron Age Ban Non Wat. At Noen U-Loke, all groups from the Early Iron Age had ornaments.

Table 47: Percentage of individuals by age according to presence of ornaments interred in burial.

	YOUNG	MID	OLDER
Combined sites	66.7%	70.6%	76.5%
Ban Non Wat	22.2%	42.9%	50%
Noen U-Loke	85.7%	92.3%	100%

Table 48: Percentage of individuals by age and site through the time phases according to presence of ornaments.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	50%	100%	46.7%	0%	77.8%	91.7%
Mid	57.1%	83.3%	54.5%	37.5%	100%	90%
Older	100%	0%	66.7%	0%	100%	100%

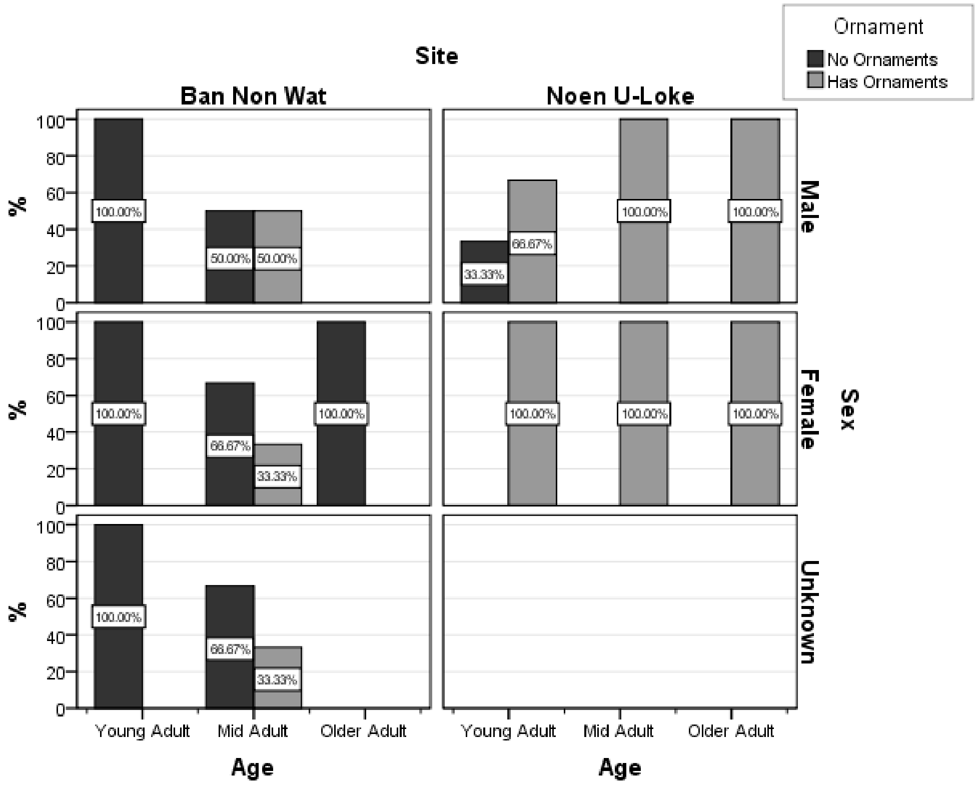

Figure 129: Percentage of individuals but age and sex at each site with/without ornaments in the Early Iron Age.

7.1.2 Blades

Noen U-Loke has a higher percentage of individuals who have been buried with blades than Ban Non Wat (Table 49 and Table 50). Only three individuals were buried at Ban Non Wat with blades. However, an increasing trend can be seen through time. In the Mid Bronze Age, no individual was buried with a blade, possibly due to their value as indispensable tools to the inhabitants.

Table 49: Percentage of burials at Noen U-Loke according to presence of blades.

EARLY IRON AGE	MID IRON AGE	COMBINED – ALL PHASES
6%	52%	35%

Table 50: Percentage of burials at Ban Non Wat according to presence of blade.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
0%	11%	19%	10%

According to sex, females are more likely to be buried with blades at Ban Non Wat, but there is no bias at Noen U-Loke (Table 51). The lone male from Ban Non Wat that has a blade dates to the Early Iron Age (Table 52). The blade is a bimetallic spear point, possibly a high value object. At Noen U-Loke, the parity of blades between the sexes can suggest equality of tasks or that the blades were purely decorative and not utilitarian in nature (Table 51). When split between the Early Iron and Mid Iron ages, there is a difference (Table 52). No females in the Early Iron Age were buried with blades, but by the Mid Iron Age half the female interments contained blades. These appear to be iron knives and sickles, possibly utilitarian and easily replaced. Only one male in Early Iron Age Noen U-Loke had blades. The individual was buried with a number of blades, both bronze and iron, which includes a hoe as well as spear heads. Mid Iron Age male burials contain iron blades, consisting of spear and arrow heads as well as knives. No hoes were identified. In an agricultural society, spear and arrow heads may be prestige goods or an indication of warfare or hunting.

Table 51: Percentage of individuals by sex according to presence of blades interred in burial.

	MALES	FEMALES
Combined sites	17%	18%
Ban Non Wat	6%	12%
Noen U-Loke	26%	25%

Table 52: Percentage of individuals by sex and site through the time phases according to presence of blades.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Females	0%	25%	6%	12%	0%	50%
Male	0%	0%	17%	25%	12%	36%

At Ban Non Wat, the few individuals with blades were all mid aged adults, whereas all age groups were represented at Noen U-Loke (Table 53). The spread of blade burials in all age groups suggests that either personal belongings were interred or that blades were becoming part of the burial ritual regardless of social identity. Young adults are the least likely to have established a social identity that influenced Noen U-Loke society as a whole. The placement of blades is suggestive, therefore, of personal attachment rather than placement as the result of the influence of living relatives. There is very little difference between age groups from Ban Non Wat and Noen U-Loke in the Early Iron Age (Table 54). The Mid Iron Age is different from any other period, as stated previously, which is suggestive of a more personal burial ritual where the possessions of the dead appear more likely to have been buried with the individual, probably based on the ease of manufacture. Prior to this period only mid aged adults, possibly influential people, were buried with blade implements.

Table 53: Percentage of individuals by age according to presence of blades interred in burial.

	YOUNG	MID	OLDER
Combined sites	20%	29%	18%
Ban Non Wat	0%	19%	0%
Noen U-Loke	29%	46%	33%

Table 54: Percentage of individuals by age and site through the time phases according to presence/absence of blades.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	0%	0%	0%	0%	0%	50%
Mid	0%	17%	36%	37%	33%	50%
Older	0%	0%	0%	0%	0%	60%

The sexes of the different age groups may also provide additional information (Figure 130). As stated previously, there are only mid aged adults with blades at Ban Non Wat, of which there are more females than males, although this sample is small (n=3). At Noen U-Loke, the blades found in the young adult burials in the Mid Iron Age belong to both males and females, as for the other age groups. This appears to confirm that there is no age or sex differentiations as to whether or not an individual is buried with a bladed item.

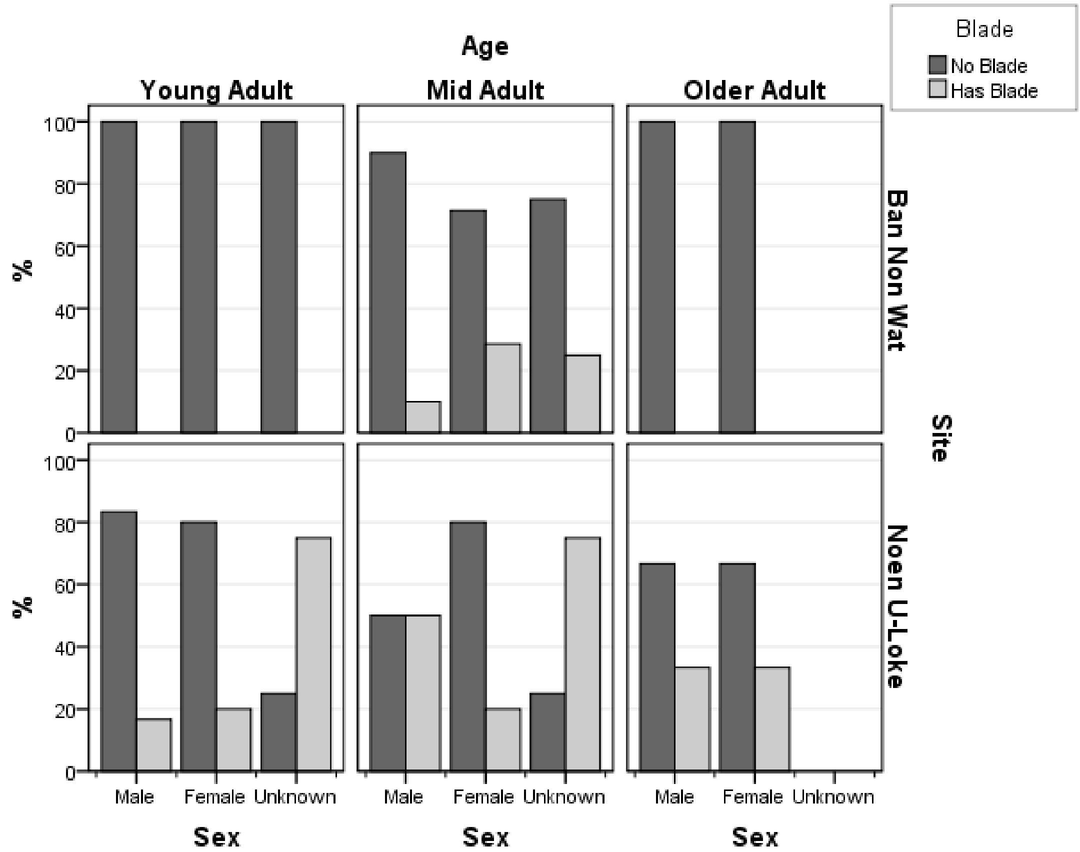

Figure 130: Percentage of individuals with/without blade items according to age and sex at each site.

7.1.3 Pottery

There is a distinct difference in phases evident at Noen U-Loke and there is an increase of burials with pottery through time (Table 55). The majority of burials in the Early Iron Age do not have pottery, but this result is reversed in the Mid Iron Age. Within all of the phases within Ban Non Wat, the majority of burials include pottery (Table 56). Through time, however, the percentage of individuals at Ban Non Wat with pottery decreases. All of the samples from the Mid Bronze Age have pottery (n=13), whereas a quarter of the samples from the Early Iron Age of Ban Non Wat do not have pottery.

Table 55: Percentage of burials at NUL according to presence of pottery.

EARLY IRON AGE	MID IRON AGE	COMBINED – ALL PHASES
31%	66%	33%

Table 56: Percentage of burials at Ban Non Wat according to presence of pottery.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
100%	89%	75%	87%

At the site of Ban Non Wat, all male burials contained pottery (Table 57), whereas only approximately half of the male burials at Noen U-Loke included pottery. In addition, at Noen U-Loke, females were less likely to have pottery, as less than half the female sample was buried with pottery, whilst most of the females at Ban Non Wat had pottery. Whilst pottery production is considered to be a female activity, the presence of pottery does not appear to be related to occupation (Higham, 2006). At Noen U-Loke, there is a distinction in the presence of pottery in female graves between the Early and Mid Iron Age (Table 58).

Table 57: Percentage of individuals by sex according to presence of pottery interred in burial.

	MALES	FEMALES
Combined sites	74%	64%
Ban Non Wat	100%	82%
Noen U-Loke	53%	44%

Table 58: Percentage of individuals by sex and site through the time phases according to presence of pottery.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Males	100%	100%	66%	100%	50%	55%
Female	100%	75%	44%	75%	12%	75%

The majority of individuals at Ban Non Wat that have pottery are mid or older adults (Table 59). All older adults were buried with pottery, but just over half of young adults had pottery. At Noen U-Loke, there is very little difference between age groups, although the mid adult group has the highest percentage. Unlike the pattern at Ban Non Wat, the pattern at Noen U-Loke does not suggest that social identity, such as age or influence of the individual motivated the placement of pottery in the burial. This is particularly noticeable in the increase of pottery in young adults in the change from Early to Mid Iron Age (Table 60).

Table 59: Percentage of individuals by age according to presence of pottery interred in burial.

	YOUNG	MID	OLDER
Combined sites	50%	82%	76%
Ban Non Wat	55%	95%	100%
Noen U-Loke	48%	62%	55%

Table 60: Percentage of individuals by age and site through the time phases according to presence of pottery.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	100%	0%	33%	50%	22%	67%
Mid	100%	100%	73%	88%	33%	70%
Older	100%	100%	67%	100%	50%	60%

7.1.4 Animal Bone

Over half the Noen U-Loke Early Iron Age sample contained animal bone, but no animal bone can be found in the Mid Iron Age samples (Table 61). This shows a drastic change in burial ritual with the significance of animal offerings being lessened. The earlier time phases at Ban Non Wat show a low percentage of animal bone in the Bronze Age periods and a sharp increase in the Iron Age (Table 62). The percentage of individuals in the Early Iron Age differs between the sites. Ban Non Wat has a higher proportion of individuals with animal bone. The Early Iron Age is an important period with regard to animal bones and animal offerings are a significant part of the burial ritual at this time. The reason for this is unclear. There is little difference between males and females at Ban Non Wat overall, or at Noen U-Loke (Table 63), although more females than males have animal bone at the latter site.

Table 61: Percentage of burials at NUL according to presence of animal bone.

EARLY IRON AGE	MID IRON AGE	COMBINED – ALL PHASES
56%	0%	21%

Table 62: Percentage of burials at Ban Non Wat according to presence of animal bone.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
38%	33%	75%	53%

Table 63: Percentage of individuals by sex according to presence of animal bone interred in burial.

	MALES	FEMALES
Combined sites	37%	42%
Ban Non Wat	56%	53%
Noen U-Loke	21%	31%

Within the Bronze Age sample from Ban Non Wat half of the male sample had animal bone (Table 64). This increases markedly in the Iron Age. Females in Bronze Age Ban Non Wat have a considerably lower prevalence of animal bone but in the Iron Age the percentage of females interred with animal bone increases markedly and overtakes that of the male sample. This suggests that sex has a large influence on whether or not animal offerings are placed in the grave during the Bronze Age, but there is a change in ritual behaviour in the Iron Age. Whilst all age groups are represented at both sites (Table 65), mid adults predominate within Ban Non Wat, suggesting that achieved social identity, where mid adults would have the most influence on society, guides whether or not there is the presence of animal offerings. Older adults in Early Iron Age Noen U-Loke are more likely to have animal offerings than young or mid adults (Table 66), and young and older females are also well represented (Figure 131). This is different from Ban Non Wat and may suggest that the animal offerings are respectful, familial or groups based offerings, rather than an expression of the influence of the individual, although all older adults in the Early Iron Age have animal offerings in Ban Non Wat. The Early Iron Age, therefore, sees a change in burial ritual, moving from achieved status to familial/group or assigned status.

Table 64: Percentage of individuals by sex and site through the time phases according to presence of animal bone.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Male	50%	50%	58%	75%	50%	0%
Female	20%	25%	75%	88%	63%	0%

Table 65: Percentage of individuals by age according to presence of animal bone interred in burial.

	YOUNG	MID	OLDER
Combined sites	23%	47%	35%
Ban Non Wat	33%	67%	37%
Noen U-Loke	19%	15%	33%

Table 66: Percentage of individuals by age and site through the time phases according to presence of animal bone.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	0%	0%	47%	50%	45%	0%
Mid	57%	50%	82%	88%	67%	0%
Older	25%	0%	83%	100%	75%	0%

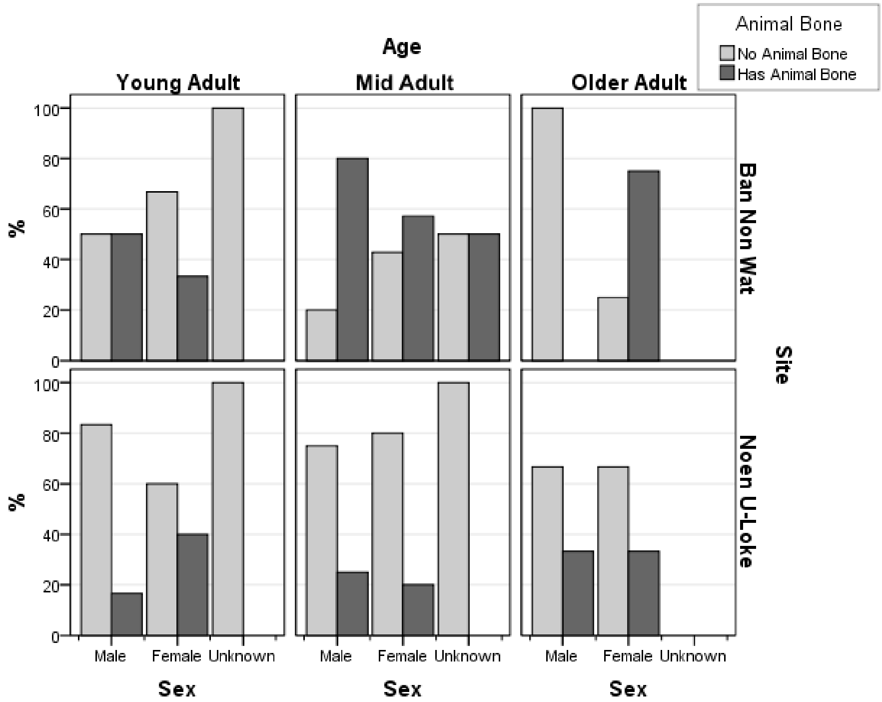

Figure 131: Percentage of individuals with/without animal bone according to age and sex at each site.

7.1.5 Industrial Goods

The peak of individuals buried with industrial goods is during the Late Bronze Age of Ban Non Wat and by the Mid Iron Age at Noen U-Loke few have industrial goods (Table 67 and Table 68). The industrial goods at Ban Non Wat are varied, but are found in each phase and mainly relate to the production of textiles and pottery but also metal goods. Overall, males and females at Ban Non Wat are equally represented with industrial goods (Table 69). However, in the Mid Bronze Age sample, only males had industrial goods, all of which are related to metal production. In the Late Bronze Age, no males in the sample had industrial goods (Table 70). This suggests that metal working was possibly a prestigious occupation in the Mid Bronze Age, where there were few specialists who were highly regarded. By the Late Bronze Age, perhaps, metal working become less prestigious and more commonly practiced which is why no metal work goods were placed in the graves of males. No metal working goods were found in Iron Age Ban Non Wat.

Noen U-Loke, however, only contains industrial goods relating to textile production. The majority of those burials with industrial goods were females at Noen U–Loke in both Iron Age periods (Table 69 and Table 70). If there was any pottery or metal production at Noen U-Loke, it is not evident in the burials goods sample.

Table 67: Percentage of burials at NUL according to presence of industrial goods.

	EARLY IRON AGE	MID IRON AGE	COMBINED – ALL PHASES
Presence	25%	11%	19%

Table 68: Percentage of burials at Ban Non Wat according to presence of industrial goods.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
23%	45%	35%	32%

Table 69: Percentage of individuals by sex according to presence of industrial goods interred in burial.

	MALES	FEMALES
Combined sites	20%	30%
Ban Non Wat	31%	29%
Noen U-Loke	10%	31%

Table 70: Percentage of individuals by sex and site through the time phases according to presence of industrial goods.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Males	37%	0%	25%	50%	12%	9%
Female	0%	75%	31%	25%	37%	25%

The age groups at both Ban Non Wat and Noen U-Loke that contain industrial goods are similar (Table 71). Mid and older adults comprise the majority of people with these goods. This is suggestive that they were the owners of the tools. The small number of young adults (n=2) with textile production goods suggests that they were also textile workers. This was not a customary burial offering for young adults and, as such, the objects must have had some meaning to the dead individual or their family. Industrial goods in young adult graves are only evident in the Early Iron Age (Table 72).

Table 71: Percentage of individuals by age according to presence of industrial goods interred in burial.

	YOUNG	MID	OLDER
Combined sites	7%	35%	35%
Ban Non Wat	11%	38%	37%
Noen U-Loke	5%	25%	25%

Table 72: Percentage of individuals by age and site through the time phases according to presence of industrial goods.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	0%	0%	13%	27%	11%	0%
Mid	29%	50%	45%	37%	33%	20%
Older	25%	50%	37%	50%	25%	40%

7.1.6 'Other' Goods

"Other" goods are those goods that are not common, such as clay objects or rice that cannot be easily classified. This is included so that any patterns showing non-conforming or non-customary burial ritual can be identified. The percentage of individuals with 'other' types of burial goods decreases through time. This occurs in both sites (Table 73 and Table 74). The Mid Iron Age is the only period where less than half the sample has 'other' types of goods. Table 75 show the type of goods found and that the variety of goods decreases over time. The artefacts show little intra-site difference, but there are inter-site dissimilarities, which is exemplified in the Early Iron Age. Rice is not part of the burial ritual in Ban Non Wat, but prominent in Noen U-Loke, where a bed of rice was commonly laid. Lumps of grey clay are also only seen as grave goods at Ban Non Wat. The significance of the clay is not known.

There appears to be no bias in the placement of 'other' goods according to sex at either site (Table 76). This pattern can be seen in all phases (Table 77). The percentage ratio of males to females with 'other' goods is fairly even, and in the Mid Iron Age, the drastic drop of 'other' goods is reflected in both sexes. More differences can be seen between the two sites in the comparison of age groups and the presence of 'other' burial goods (Table 78). At Ban Non Wat, older adults have the highest percentage of individuals with 'other' goods and younger adults have the lowest. This suggests that additional and possibly highly significant burial goods are placed in the graves of individuals who have garnered a high level of respect in the society, which are more likely to have been the elderly. Alternatively, older individuals have had a longer time to accumulate personal possessions. In Noen U-Loke, however, the percentage of older adults who have 'other' burial goods is lower than that of young adults. Mid adults have the highest percentage of individuals with 'other' goods. This is suggestive of the use of 'other' goods for individuals who would have been at their peak of productivity and therefore their loss is keenly felt.

The different goods used and the different burial rituals at the two sites hints that there is more than just a short physical distance between the two sites. There appears be a fundamental difference in burial ritual between the two sites based on the presence of 'other' goods. Looking more closely at the Early Iron Age (Table 79), all older adults are buried with "other" goods at Ban Non Wat, compared with only half of the older adults at Noen U-Loke.

Table 73: Percentage of burials at NUL according to presence of goods classified as 'other'.

EARLY IRON AGE	MID IRON AGE	COMBINED – ALL PHASES
69%	37%	48%

Table 74: Percentage of burials at Ban Non Wat according to presence of goods classified as 'other'.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	COMBINED – ALL PHASES
85%	78%	69%	76%

Table 75: 'Other' types of burial goods found in Ban Non Wat and Noen U-Loke according to phase.

	MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	MID IRON AGE
Ban Non Wat	Unidentifiable copper alloy objects	Unidentifiable copper alloy objects	Unidentifiable iron objects	
	Ochre	Ochre	Ochre	
	Bivalves	Bivalves	Bivalves	
	Clay pellets	Clay pellets		
	Fibres			
	Grey clay	Grey clay	Grey clay	
	Sandstone			
	Wood	Wood		
Noen U-Loke			Unidentifiable copper alloy objects	Unidentifiable copper alloy objects
			Ochre	
			Bivalves	Bivalve
			Rice	Rice

Table 76: Percentage of individuals by sex according to presence of goods classified as 'other' interred in burial.

	MALES	FEMALES
Combined sites	63%	64%
Ban Non Wat	81%	76%
Noen U-Loke	47%	50%

Table 77: Percentage of individuals by sex and site through the time phases according to presence of goods classified as 'other'.

	MID BRONZE AGE– BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Males	88%	75%	67%	75%	63%	36%
Female	80%	75%	75%	75%	75%	25%

Table 78: Percentage of individuals by age according to presence of goods classified as 'other' interred in burial.

	YOUNG	MID	OLDER
Combined sites	53%	71%	59%
Ban Non Wat	67%	76%	88%
Noen U-Loke	48%	62%	33%

Table 79: Percentage of individuals by age and site through the time phases according to presence of goods classified as 'other'.

	MID BRONZE AGE – BAN NON WAT	LATE BRONZE AGE– BAN NON WAT	EARLY IRON AGE COMBINED	EARLY IRON AGE – BAN NON WAT	EARLY IRON AGE – NOEN U-LOKE	MID IRON AGE – NOEN U-LOKE
Young	100%	0%	67%	67%	67%	33%
Mid	86%	83%	73%	63%	100%	50%
Older	75%	100%	67%	100%	50%	20%

7.1.7 Number of Variables

The number of variables (ornament, pottery, industrial goods, blade, animal bone, and other) that may be placed within the grave may indicate an aspect of burial ritual and the society. There appears to be little difference between males and females in each time phase as measured by the mean number of variables in each sub-sample (Figure 132). There is a difference, however, in the age groups (Figure 133). Young adults in the Late Bronze Age and Early Iron Age of Ban Non Wat, as well as those in the Early Iron Age of Noen U-Loke have less variability in good types. This is statistically significant as a one way ANOVA showed $F(2,78)= 6.891$, $p<0.05$. Why there is less variability as opposed to mid and older adults is unclear. Perhaps this may be due to the shorter amount of time given to develop a unique social identity.

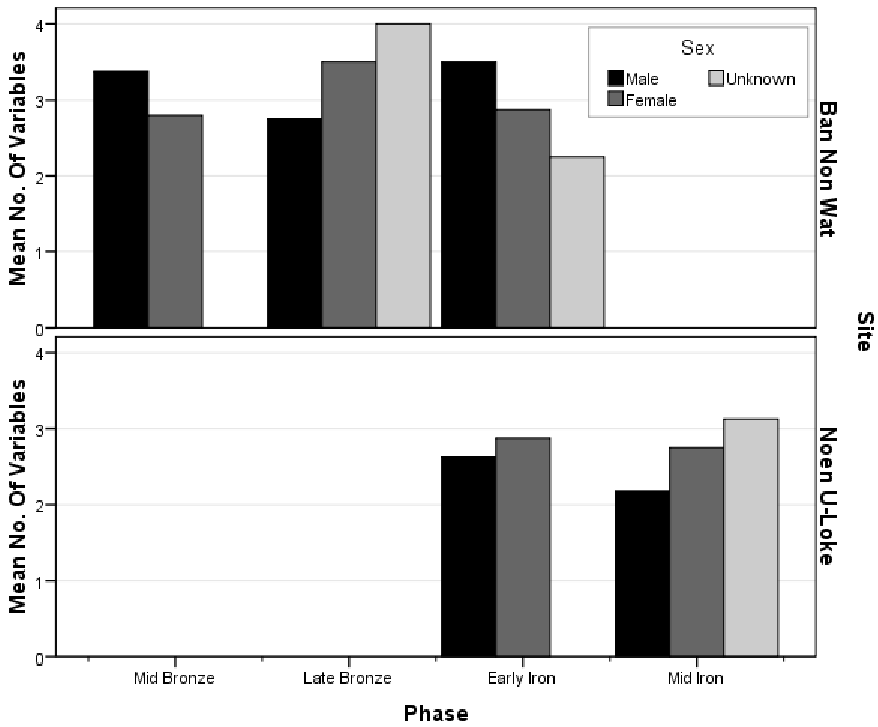

Figure 132: Mean number of variables according to sex during each phase and site.

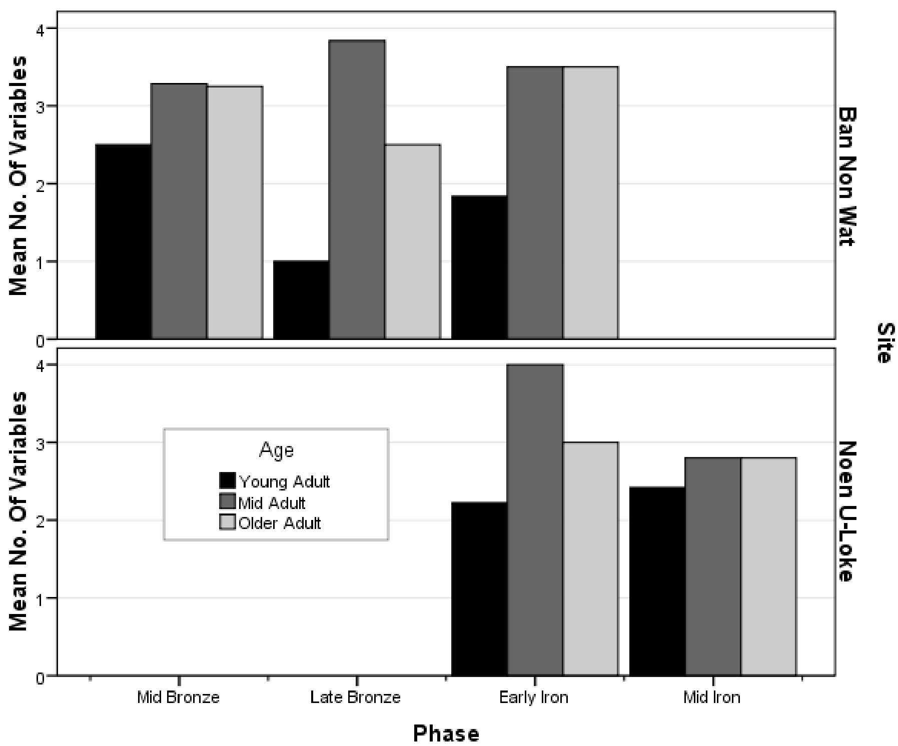

Figure 133: Mean number of variables according to age during each phase and site.

7.1.8 Orientation of the body

The head orientation of the Ban Non Wat sample was obtained from the excavation burial register, and those from Noen U-Loke were extracted from the Noen U-Loke report (Higham, 2002). The site of Ban Non Wat is dominated by burials orientated with their heads to the north (Table 80). The Mid Bronze Age is dominated by north orientated burials, but by the Early Iron Age at Ban Non Wat, south oriented burials become more common (Table 81). Burials at Noen U-Loke are more diverse, with the majority to the north, followed closely by north-east and south (Table 80), and when divided into Early and Mid Iron Age, there is a distinct difference between the phases (Table 81).

Table 80: Orientation of burials at Ban Non Wat and Noen U-Loke. Direction indicates where the head is positioned.

NO OF INDIVIDUALS		ORIENTATION				
		NORTH	NORTH EAST	EAST	SOUTH	TOTAL
Site	**Ban Non Wat**	21 (55%)	0	6 (16%)	11 (29%)	38
	Noen U-Loke	15 (35%)	12 (28%)	5 (12%)	11 (26%)	43

The orientation of males and females at Ban Non Wat is similar, but the east oriented burials appear to have some bias towards sex (Table 82 and Table 83). Whilst there is a small east oriented sample, only older males face east in the Mid Bronze Age, but in the following phases only females face east. In the Late Bronze Age the east oriented females are mid or older adults, but in the Early Iron Age a young female is buried oriented east. It may be surmised that burying a body oriented east, against the customary north-south burials is a significant ritual. The reasoning behind the ritual is unknown. A cursory examination of the burial goods placed with the females in the Late Bronze Age, shows that the young female buried in the north position had only a fragmented bangle, whilst those buried in the east position were in stark contrast by being interred with numerous and various burial offerings. The three in the Late Bronze Age are also buried close to each other and may represent a societal sub-group, but this is only speculative. This could be related to ascribed, occupational or other self-contrived groups or social identities. At Noen U-Loke, there appears to be no bias in the orientation of the head according to sex or age (Table 84 and Table 85).

Table 81: Orientation of burials according to phase.

NO OF INDIVIDUALS PHASE			ORIENTATION				TOTAL
			NORTH	NORTH EAST	EAST	SOUTH	
Mid Bronze	Site	Ban Non Wat	11 (85%)		2 (15%)		13
		Total	11		2		13
Late Bronze	Site	Ban Non Wat	5 (56%)		3 (33%)	1 (11%)	9
		Total	5		3	1	9
Early Iron	Site	Ban Non Wat	5 (31%)	0	1 (6%)	10 (63%)	16
		Noen U-Loke	1 (6%)	12 (75%)	3 (19%)	0	16
		Total	6	12	4	10	32
Mid Iron	Site	Noen U-Loke	14 (52%)		2 (7%)	11 (41%)	27
		Total	14		2	11	27

Table 82: Orientation of burials at Ban Non Wat according to phase and sex.

PHASE			ORIENTATION			TOTAL
			NORTH	EAST	SOUTH	
Mid Bronze	Sex	Male	6	2		8
		Female	5	0		5
		Total	11	2		13
Late Bronze	Sex	Male	3	0	1	4
		Female	1	3	0	4
		Unknown	1	0	0	1
		Total	5	3	1	9
Early Iron	Sex	Male	1	0	3	4
		Female	1	1	6	8
		Unknown	3	0	1	4
		Total	5	1	10	16

Table 83: Orientation of individuals buried at Ban Non Wat according to age and phase.

PHASE		ORIENTATION			TOTAL
		NORTH	EAST	SOUTH	
Mid Bronze Age	Young adult	2	0		2
	Mid adult	7	0		7
	Older adult	2	2		4
	Total	11	2		13
Late Bronze Age	Young adult	1	0	0	1
	Mid adult	3	2	1	6
	Older adult	1	1	0	2
	Total	5	3	1	9
Early Iron Age	Young adult	3	1	2	6
	Mid adult	2	0	6	8
	Older adult	0	0	2	2
	Total	5	1	10	16

Table 84: Orientation of burials at Noen U-Loke according to sex and phase.

PHASE		ORIENTATION				TOTAL
		NORTH	NORTH EAST	EAST	SOUTH	
Early Iron Sex	Male	1	5	2		8
	Female	0	7	1		8
	Total	1	12	3		16
Mid Iron Sex	Male	6		1	4	11
	Female	6		1	1	8
	Unknown	2		0	6	8
	Total	14		2	11	27

Table 85: Orientation of burials at Noen U-Loke according to age and phase.

PHASE		ORIENTATION				
		NORTH	NORTH EAST	EAST	SOUTH	TOTAL
Early Iron Age	Young adult	1	7	1		9
	Mid adult	0	2	1		3
	Older adult	0	3	1		4
	Total	1	12	3		16
Mid Iron Age	Young adult	6		0	6	12
	Mid adult	4		1	5	10
	Older adult	4		1	0	5
	Total	14		2	11	27

7.1.9 Number of artefacts

Using counts for the number of artefacts as a measure of status is problematic. It is difficult to understand the differences between individuals by comparing counts. Comparing an individual from the Bronze Age and the Iron Age and trying to determine status can be counterproductive. If the burial rituals of the Bronze Age differ from that of the Iron Age, a direct comparison cannot be made. By understanding what is the norm for groups direct comparisons may not still be able to be made, but intra-group differences may be distinct and offer an understanding of the differences. What may be measured is the availability of goods rather than burial ritual differences. If commonly available products are not available in certain time periods are comparisons valid? By looking at groups and temporal patterns, perhaps the differences can be better understood.

The Mid Iron Age is distinctly different from earlier time periods (Figure 134). Whilst the Bronze ages and the Early Iron Age see a similar mean number of artefacts, the Mid Iron Age has a considerably higher number, and double that of the Early Iron Age. This may be the result of goods availability rather than a change in ritual behaviour. The difference between the phases, however, is not statistically significant when a Kruskal-Wallis Test is undertaken ($\chi^2[3,\underline{N}=81]=4.122$, $p>0.05$). Other patterns in phases can also be seen in Table 86. All interments in the Bronze Age received a burial item, whereas in the Iron Age, some did not have any items. The highest numbers of burial goods is fairly similar in the Bronze Age but rises sharply in the Iron Age. The question that needs to be asked is whether there is a change in the type of burial goods being placed in Iron Age burials that requires larger numbers to be placed with the dead? Is it a change in burial ritual? Does the value of burial goods change? Does the

Iron Age have more modern ideas of value, more goods equating to higher worth? Are ten bangles more valuable than only one? Is the symbolic value of goods more important in the Bronze Age? Where 10 bangles or one bangle has the same meaning, for example, a bangle could symbolise coming into marriageable age. The number of bangles is meaningless.

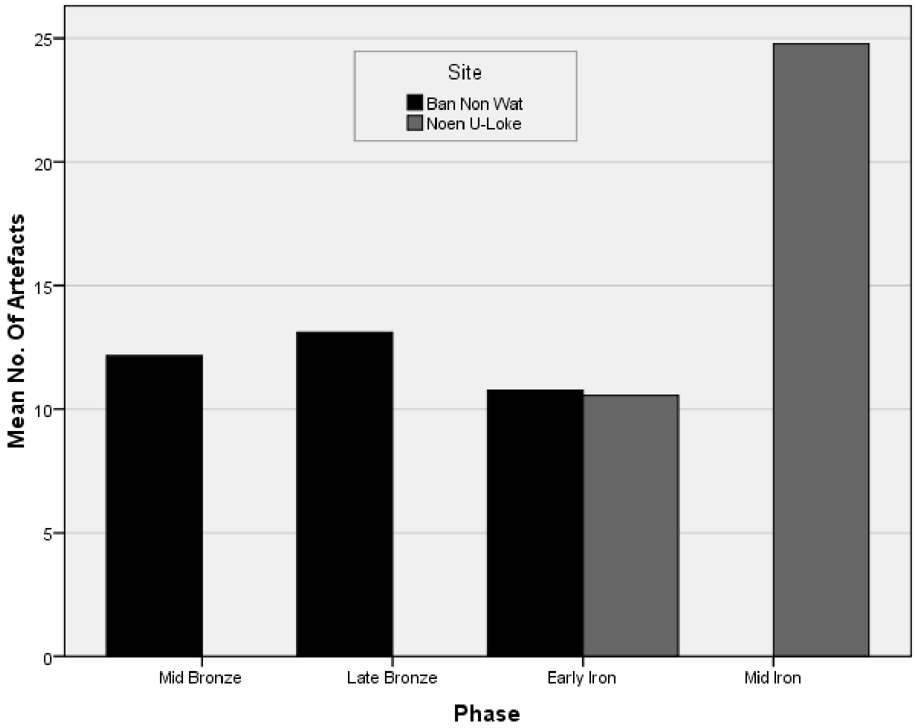

Figure 134: Mean number of artefacts according to phase at Ban Non Wat and Noen U-Loke.

Table 86: Descriptive statistics for number of artefacts according to phase.

PHASE	N	MINIMUM	MAXIMUM	MEAN
Mid Bronze	13	4.00	27.00	12.1538
Late Bronze	9	1.00	23.00	13.1111
Early Iron	32	.00	53.00	10.6563
Mid Iron	27	.00	141.00	24.7778
Total	81	.00	141.00	15.8765

When the sexes are separated in phase groups, there is little difference, although overall in each phase, females on average have less artefacts (Figure 135). Again, there is no statistical significance between the phases according to sex (males - $\chi^2[3,\underline{N}=35]=3.605$, $p>0.05$ and females- $\chi^2[3,\underline{N}=33]=4.376$, $p>0.05$). There are also no statistically significant differences between males and females in each phase (Mid Bronze Age - $t[11]=1.895$, $p>0.05$, Late Bronze Age $t[6]=1.394$, $p>0.05$, Early Iron Age $t[26]=0.509$, $p>0.05$ and Mid Iron Age $t[17]=0.092$, p>0.05).

An examination of the mean number of artefacts in each phase by age groups sees mid adults dominate in most phases, except the Mid Bronze Age, where older adults have more artefacts on average (Figure 136). This may suggest that respect for elders played a part in the placement of artefacts in the burials in the Mid Bronze Age, or that they had developed a larger network of relationships. There are no statistically significant differences between the age groups in the difference phases, except for the Early Iron Age. There is a statistically significant difference between young and mid adults in the Early Iron Age (χ^2[1,N=26]=7.892, p<0.05), which stems from the site of Ban Non Wat (t[12]=-2.595, p<0.05). There is no statistical difference between young and mid adults in Noen U-Loke in the Early Iron Age. By the Mid Iron Age, young adults had more artefacts on average than older adults. Does this suggest that status is not achieved through contribution to society but acquired by group association, such as a family or occupation? This pattern is similar to that seen in the distribution of pottery (Table 60) and 'other' goods (Table 79).

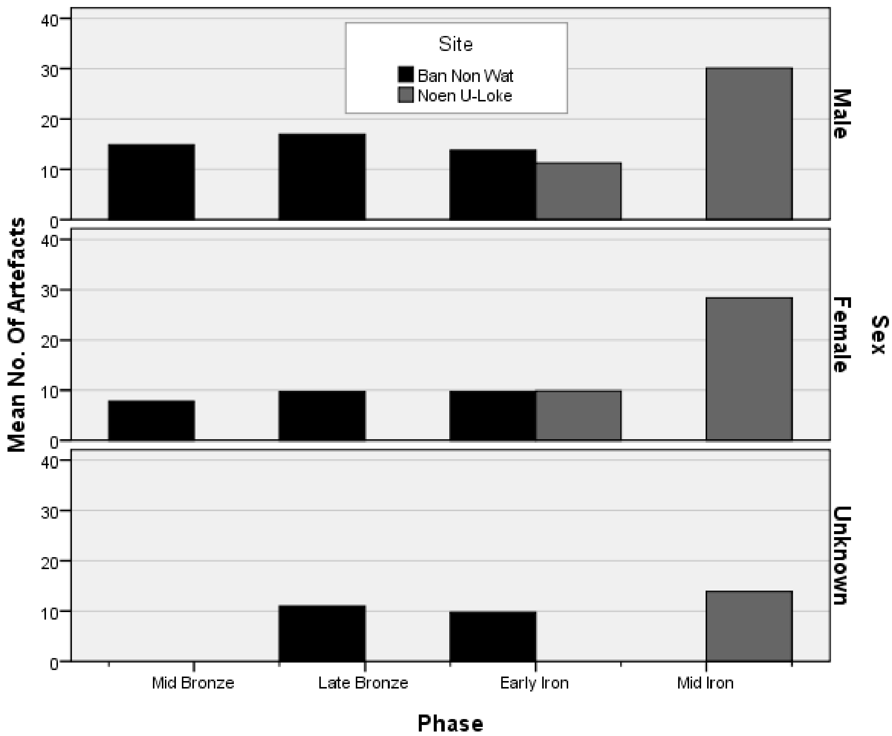

Figure 135: Mean number of artefact according to sex and phase.

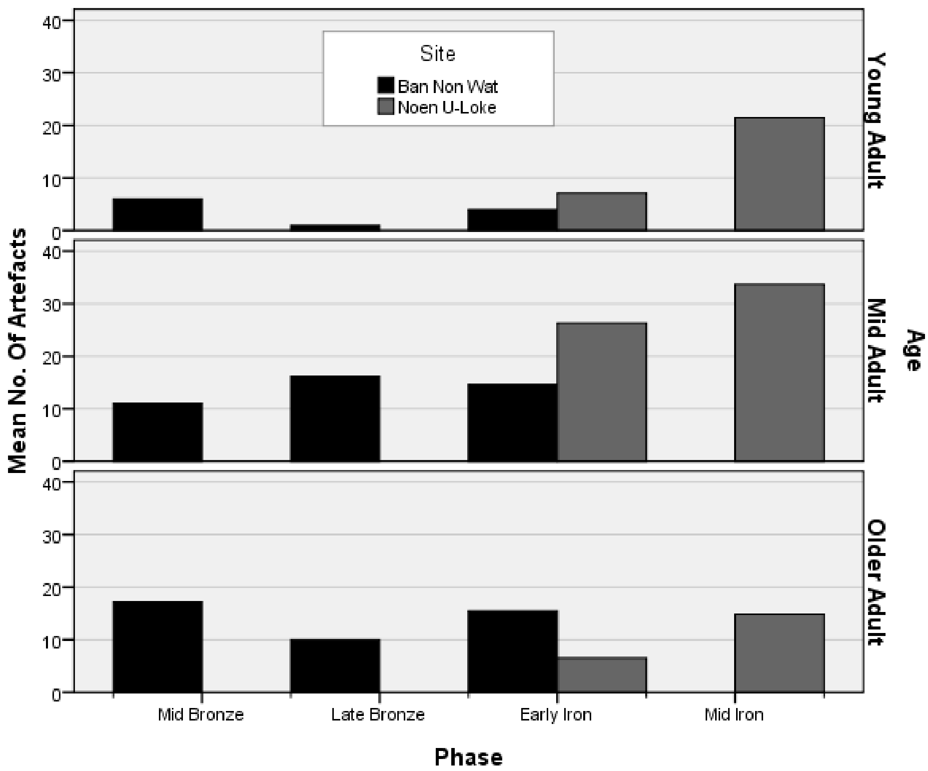

Figure 136: Mean number of artefacts according to phase and age.

7.1.10 Number of ornaments

Are the results regarding the mean number of artefacts seen in Chapter 7.1.9 related to ornaments and their possible domination in the archaeological record? Are ornaments influencing the results? Figure 137 shows that, with the exception of the Mid Iron Age, ornaments do not dominate the archaeological record. This suggests that the Mid Iron Age is distinctly different in burial ritual compared with previous periods, but again this may be related to the availability of ornaments. Perhaps they are being mass produced in the Mid Iron Age.

Over time, Ban Non Wat sees a gradual drop in the average number of ornaments, but Noen U-Loke is distinctly different (Figure 138). The burial ritual at Noen U-Loke comprises larger numbers of ornaments and the Mid Iron Age sees a marked increase in them. The difference between the Mid Iron Age and earlier periods is statistically significant ($\chi^2[3,\underline{N}=81]=23.097$, $p<0.05$). Could this be the result of a different cultural group settling at Noen U-Loke or that ornament availability was an issue at Ban Non Wat or prior to the Mid Iron Age? Even during the same period, the Early Iron Age, ornaments were few at Ban Non Wat, so perhaps the difference in function of the two locales is what is visible at this time. Perhaps Noen U-Loke was involved in trade at a higher level than Ban Non Wat was. This may reflect Noen U-Loke as a central community and Ban Non Wat as a peripheral community in the local social system.

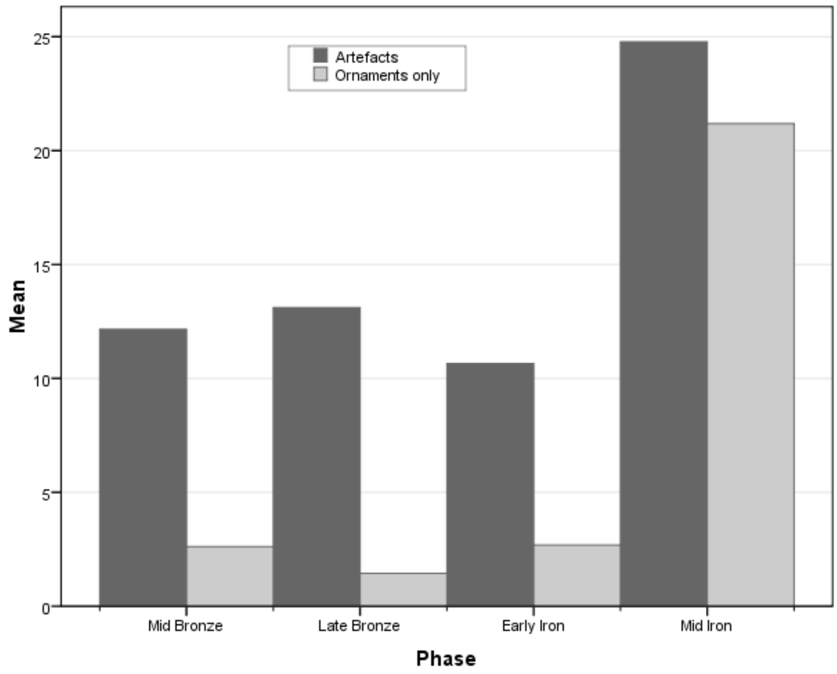

Figure 137: Mean number of ornaments and artefacts according to phase.

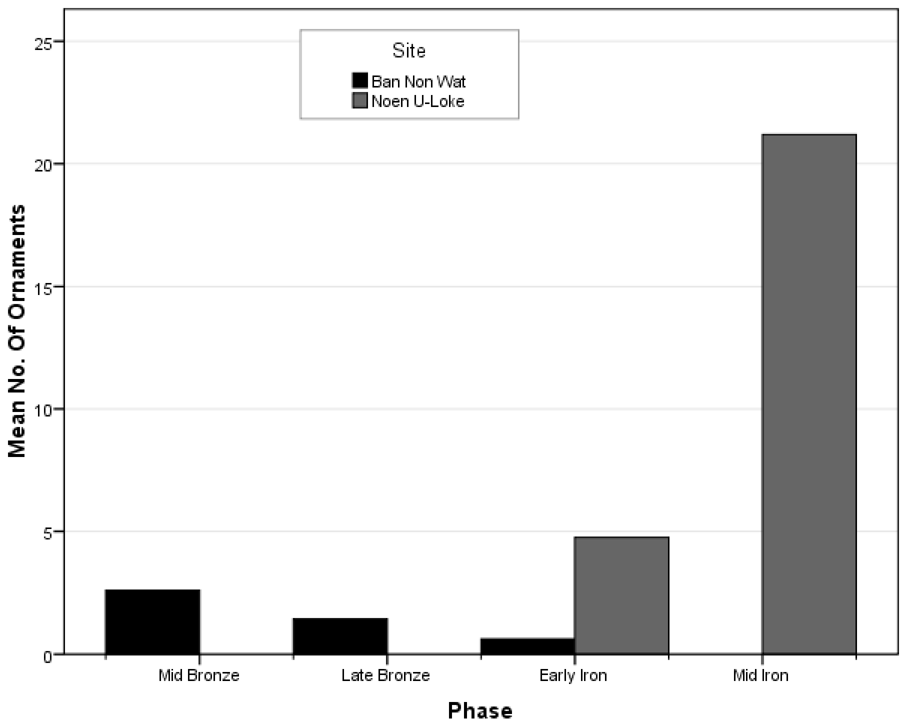

Figure 138: Mean number of ornaments according to phase.

Figure 139 shows the breakdown of mean numbers of ornaments by sex. The Early Iron Age of Noen U-Loke is the only period where there is a distinct difference between the sexes. Females have more ornaments on average than males. This difference is not statistically significant ($t(14)= 2.193$, $p>0.05$). In the examination of age and ornaments, the Mid Bronze Age shows an inclination towards a higher mean of ornaments for older adults, whilst the Iron Age shows higher numbers of ornaments in mid adults. There is a significant statistical difference between older adults and young/mid adults in the Mid Bronze Age ($F [2,10]=35.5$, $p<0.05$). This may suggest that in the Mid Bronze Age, older adults were the main recipients of ornaments and that these ornaments may have a specific meaning, perhaps an indication of familial respect or of a contribution to society, a reflection of the size of their social networks, but also perhaps that the interred had longer to obtain ornaments throughout their life and therefore are more likely to have been buried with their prized possessions. There is no statistical difference between the age groups in the Iron ages.

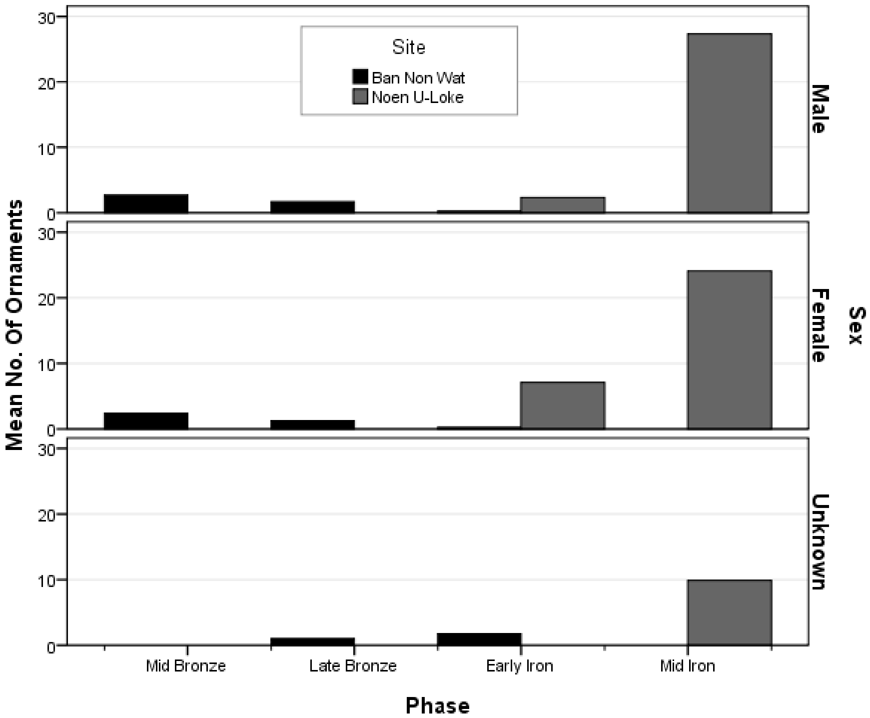

Figure 139: Mean number of ornaments according to phase, site and sex.

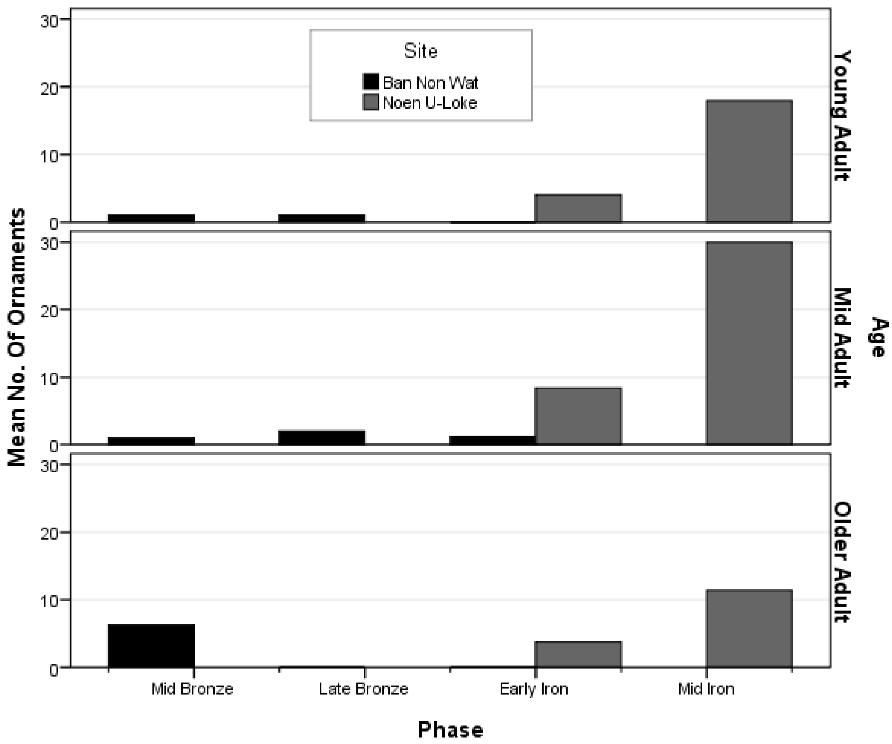

Figure 140: Mean No. of ornaments according to age, site and phase.

7.1.11 Wild Animal Burial Goods

Only two individuals from Noen U-Loke, and none from Ban Non Wat, were interred with non-domesticated animal bones. The presence of wild animal bone in these two burials may have a special significance, relating to the two individuals. The goods are not a common burial ritual item and therefore must be a special item of some significance to the interred, a young male and a mid aged male. This significance needs to be examined at an individual level rather than at a sample or population level.

7.1.12 Exotic Goods

Exotic goods are identified as being made from agate, carnelian, silver or gold. Agate and carnelian jewellery is considered to be a 'status' item as it would have been imported from other areas and formed by specialists, who used diamond tipped drills (Talbot, 2007). These goods are considered to be 'exotic' as their presence is due to long distance trade networks. The goods are not considered to be locally made or easily available. It would be difficult to use 'exotic items' as a comparative tool as this variable is an effect of trade networks. Availability of goods is an important factor and whilst it may be possible for a comparison between individuals and groups within time phases, the time phases may need to be very short, as the availability of goods from distant lands would also be variable. A number of generations comprise each time phase and during this period, trade of goods, such as agate, may not have been a possibility. What is really being tested is availability of goods rather than burial ritual differences. Exotic goods were only identified in the Noen U-Loke sample. The Iron Age is the period where it is considered that long distance trade networks effectively began, therefore comparisons with the Bronze Age are not possible, although, a comparison of the Early Iron Age of both Ban Non Wat and Noen U-Loke may be insightful. Of the 32 individuals from the samples in the Early Iron Age, only four have 'exotic goods'. These four individuals are from Noen U-Loke. They are all female and belong to all age groups. This result suggests that the Noen U-Loke population had access to trade items early in the establishment of the village. This may suggest that the founding families were migrants and brought the exotic items into the area. The inhabitants of well-established Ban Non Wat were apparently not accustomed to these goods during this period. If these goods were traded at Ban Non Wat, then the inhabitants chose not to bury their dead with these goods, suggesting a culturally different group to that at Noen U-Loke. In the Early Iron Age of Ban Non Wat, one individual in the sample has 'exotic' objects, which are blue-green glass earrings. These are likely to have been imported into the area. In the Mid Iron Age, exotic goods at Noen U-Loke can be found in all sex and age groups and no group dominates.

7.2 Interpretation of the burial goods sample

To reiterate, this interpretation is based on the same sample as that used in the Health Index sample and therefore does not include all of the available data for these sites. Many adult and all sub-adult data was excluded. This burial good analysis and interpretation is provided as comparative material for the following chapter, which shows how the SEAHI can be used in conjunction with archaeological data. It should not be considered as an overall interpretation of either Ban Non Wat or Noen U-Loke.

7.2.1 Transitional change from the Bronze Age to the Iron Age

Is there any evidence of a transition period from the Bronze to the Iron Age? Is the presence of Iron the only defining change? Can any differences between the Bronze and Iron ages be seen in the burials?

Ornamental burial goods may provide an indication of transitional change. A high proportion of the Ban Non Wat and Noen U-Loke burials are interred with ornaments. The Early Iron Age of Ban Non Wat, however, appears to be anomalous. The Mid Bronze Age is characterised by ornaments in all age groups, especially older adults. This perhaps shows a familial aspect to the interment of goods. In the Late Bronze Age, no older adults have ornamental goods, which can be found mainly in mid adult burials. Therefore, it may be surmised that ornament offerings may be considered either unusual or special in the Late Bronze Age. Mid adults would have gained knowledge and influence through familial channels as well as through achieved status and wealth accumulation. Younger adults would have yet to attain this, and older adults may have no longer been high societal contributors.

Familial connections do not appear to be a factor in the placement of ornaments in the Early Iron Age at Ban Non Wat. The Early Iron Age of Ban Non Wat sees few individuals with ornaments, all of which are mid adults. Young and older adults did not receive ornamental offerings. This may suggest that ornaments were only placed in the graves of those with a high social standing that existed at the time of their death. These mid adult males and females would have been at the peak of their influence and ability to contribute to society, and may have been the people that would have had the most influence on that society. This appears to be a change in burial ritual from ascribed status to that of acquired status. This may also suggest a number of other variables, including incoming migration of other influential cultures along with the new iron technology. Whilst these variables can be considered, the site of Noen U-Loke suggests that migration as a variable may not be applicable. Noen U-Loke at the same time period, Early Iron Age, appears to be conducting a different manner of burial ritual.

Ornaments are a common burial item in the Early Iron Age of Noen U-Loke. The placement of ornaments in the graves of the young adults in Noen U-Loke reflects the loss of those who had not fulfilled their potential, especially young males. A high proportion of young and older females with ornaments can be explained in a number of ways in relation to social identity. The loss of young, fertile, females could have been devastating to a village that was still in its beginnings and the loss of older females perhaps related to loss of knowledge and familial stability and support to the younger fertile generation. Does this suggest that the Late Bronze to Early Iron Age period of Ban Non Wat is different to that of Noen U-Loke? A possible interpretation for the high percentage of ornaments in Noen U-Loke burials compared to that of Ban Non Wat in the same time period could be attributed to Noen U-Loke being a regional centre, with more developed trade and opportunities for the purchase of ornaments and Ban Non Wat a peripheral village. However, this interpretation does not correlate with Noen U-Loke as an emerging community in the Early Iron Age, whereas Ban Non Wat is already well established. The difference at Ban Non Wat is suggestive of political or stratigraphic influences in burial ritual, including a change in the composition of society and its structure. Family connections, which would have seen older and younger adults interred with ornaments, do not seem to be important in this transition period in Ban Non Wat.

If we focus on the Early Iron Age of Ban Non Wat and assume those with ornaments are considered to be people of importance, can we see this reflected in the other goods and variables that they have? Based on the goods interred with these three individuals, there is no distinct similarity between them (Table 87). BNW231 has industrial goods relating to weaving as well as pottery production. Does this suggest that this person was an artisan, had a family connection to an industrial business or that he had some controlling interest in these industries? No industrial connotations are found with the female BNW237. She has glass earrings, which may be considered a prestige item, due to their relationship with long distance trade networks. These earrings may not have been a daily adornment, however, and may have been made purely for the burial ritual. It is possible that the delicacy of glass would not have allowed their daily use. This single trade item makes this individual unique. BNW382, of unknown sex, was only interred with bangles. However, these are numerous and made of bronze, ivory and the new metal, iron. This person is unusual in that there are no pots interred. Pots are a common burial item in the Early Iron Age of Ban Non Wat. The burial is dissimilar to the burials of Ban Non Wat at the same period where ornaments play a prominent role in the burial ritual. Is this person a migrant? A merchant who died away from home?

Table 87: Listing of items found with Early Iron Age mid adults at Ban Non Wat.

	BNW231 MALE	BNW237 FEMALE	BNW382 UNKNOWN
Ornaments	Trochus Bangle	Glass Earrings	Numerous bronze, iron and ivory bangles
Pottery	4 pots	6 pots	None
Animal	Bovid phalanges, other animal bone	Pig rib	None
Industrial	Pottery anvil, spindle whorl	None	None
Other	None	Bivalve Shell	None
Orientation	South	South	North
No of artefacts	10	4	13
Comment	Industrial goods suggests a potter and weaver	Glass earrings are considered long distance trade items	

7.2.2 Signs of Daily Life

Can we expect to see everyday items in the burials of Ban Non Wat and Noen U-Loke? Whilst it can be hard to identify conclusively what items were worn or used everyday by the interred individual, there has been some thought given to everyday ornamental items in the burial records of Noen U-Loke. Within the entire excavated Noen U-Loke population, some of the jewellery found with the burials appears not to have been worn during life and are solely mortuary objects. They were made specifically for placement with the dead. This is most clearly seen in the placement of heavy, large bangles and anklets on the wrists and ankles of neonates, infants and small children (Theunissen, 2007). These could not have been worn in life. At Noen U-Loke, the jewellery found in the non-mortuary contexts is commonly made from clay or slate. There are no clay or slate jewellery objects in any of the burials (Chang, 2007). This suggests that clay and slate jewellery was worn day to day. Connelly (2007) states that iron objects were only found in mortuary contexts in early burials. As iron began to be more common and found in non-mortuary contexts, iron objects placed with burials were generally larger.

The personal ornaments found so far at Ban Non Wat can also provide valuable information about the population. For example, bangles were found interred with the dead as well as in the fill, but only those made of shell, stone and metal were placed with the dead. The clay bangles were found broken only in the fill. This suggests, as in Noen U-Loke, that the clay bangles were used on a daily basis, whilst the others may have been used solely for burial ritual. Although as shell, stone and metal bangles are more durable than clay, and relatively harder to obtain or make, they would survive longer, be cared for and not be discarded, so they still may have been used in daily life.

The blades found at both sites may also assist in understanding the complexities of a new community. Due to the condition of metal blades found in Ban Non Wat and Noen U-Loke, the exact nature or use of the blade cannot always be determined. For example, if the blade was used for domestic or agricultural purposes or as a weapon. Blades are not common burial items in the Bronze Age. In time, blades began to be buried with the dead, until the Mid Iron Age where the majority of interments contain blades. The Early Iron Age of Noen U-Loke has only one individual, a mid adult male, with a blade burial item. At the time Noen U-Loke was establishing itself as an agricultural community and perhaps could not spare the valuable blades, or production of blades was not intensive at the time. The blades in the Mid Iron Age may signify that the blades buried at this time are not utilitarian but are decorative or were made solely for the burial ritual. The other possibility is that blades became commonly made due to ease of production and replacement of any blade was easy.

As no assumptions are made as to the purpose of the blades themselves it is difficult to make statements about warfare. If the blades were all potential weapons of war, then it could be suggested that the Mid Iron Age was a violent period, but the types of blades found suggest otherwise. No sword-like or arrowhead-like blades were found. These blades will have to be more carefully analysed before any assertion can be made.

7.2.3 Immigrants? Or Availability of Goods?

A question that can be asked is whether change in burial good types, amounts or materials is related to the new arrival of people through migrations or solely due to the availability of goods. New technologies developed in the Iron Age that brought in iron goods is a simple example. Ban Non Wat exhibits a change in burial ritual in the prevalence of ornaments through time. The percentage of ornaments declines through time at Ban Non Wat. In the Bronze Age, female burials dominated the burials with ornaments. The Early Iron Age sees a sharp decrease in ornaments for both sexes, but males have a higher percentage of individuals with ornaments. This is highly suggestive of a change in burial ritual in Iron Age Ban Non Wat. This could be due to new beliefs that came with the new iron technology or an influx of immigrants, or possibly an intense and rapid change in society and the stratification or composition of that society.

There are differences in the use of pottery in the burial ritual between Ban Non Wat and Noen U-Loke. In the Iron Age, the well established community of Ban Non Wat began smashing pots over the corpse as part of the burial ritual. This practice was not evident in the Bronze Age, where pots were interred whole. This practice is described as the 'ritual killing' of the pot. Was this the result of an influx of migrants or the influence of outsiders due to the long distance trade networks and the new iron technology? Or was it an alteration in the customs of the community due to social aspects, such as establishing individual or group positions of power? The neighbouring community of Noen U-Loke was being established at this time and may be the result of a migrant influx, rather than an offshoot of Ban Non Wat or other neighbouring location. Ritualistic killing of pottery was not identified in Noen U-Loke. This suggests that the breaking of pottery was a progression of burial ritual in Ban Non Wat, and had ramifications for societal makeup.

At both sites there are other types of burial goods that appear to have specific mortuary ritual context. These objects do not appear to have any purpose beyond that of symbology. These include unthreshed rice beds (which also could be found burnt), ochre and bivalve shells, as well as grey clay. Bivalve shells are common to both sites and all periods. Ochre is found in both sites, but is not found in the Mid Iron Age. It seems that the symbology or importance of red ochre had diminished by this time, or that it was no longer available. There are items that are specific to each site. Grey clay is only found at Ban Non Wat. The purpose of this clay is unknown. It may have been a simple unfired clay figurine that has disintegrated over time or perhaps a symbolic handful of clay placed in the graves of potters. This, however, is purely speculation. At Noen U-Loke, many corpses are laid over a bed of rice. This appears to be a symbolic item. The rice harvest needed to be a rich one for rice to be used in such a fashion and not wasted. This suggests that Noen U-Loke was successful in cultivating rice crops. Whilst it may seem that this is a cultural difference between the two sites, it does not necessarily mean that the people of Noen U-Loke are culturally different to those at Ban Non Wat or are migrants. It only emphasises the difference in value of goods and crops produced by each community and the jockeying for positions of power. These families are indicating that they are wealthy in rice and therefore can afford to use it for other reasons than nutritional. This could be a new form of showing prestige or belonging to a group exhibiting power structures. There is no sex or age bias in whether or not a rice bed was part of the burial, perhaps this signifies that it is not a status item, but a common burial ritual, but it more likely signifies a sub-group symbol of status, such as a manipulated type.

A population influx may be evident in the orientation of burials. North-east orientated burials dominate the Early Iron Age but there are no north-east burials in the Mid Iron Age when the majority of burials are in a north or south orientation. All periods in both sites have some east orientated burials. The change in orientation from north to south in Ban Non Wat shows a change in burial ritual, but the change in Noen U-Loke shows a much more distinct different burial ritual change. North-east burials are not found in Ban Non Wat and do not appear to be part of a continuing evolution of burial ritual. The orientation suggest that a new population unrelated to those at Ban Non Wat established the settlement of Noen U-Loke and did not become accustomed to the regional burial ritual of a north-south burial alignment until the Mid Iron Age.

7.2.4 Industrial goods as indicators of village craft specialization

Some individuals have been interred with artefacts that have been identified as being industrial, such as tools for ceramic production. The peak of industrial goods being interred with the dead, such as those goods related to pottery or metal goods production or weaving, can be seen in the Late Bronze Age of Ban Non Wat. Mid and older females dominate the Late Bronze Age record for industrial goods. This was a change from the Mid Bronze Age where metal working goods were found in the graves of mid and older males. This suggests that metal working in the Mid Bronze Age played an important community role at the time, which was reflected in the burial ritual, but by the time of the Late Bronze Age, metal working had become more common place at Ban Non Wat in the male population - perhaps the community became a high level metal working village. The presence of industrial goods in the female sample of the Late Bronze Age may signify the importance of female craftspeople at this time. Their input into pottery making and weaving to supply the community with valuable goods provides them with a special identity. The majority of individuals were mid to older adults, which does suggest that they owned the objects. In the Iron Age, as the production of all types of goods becomes more commonplace, the presence of industrial goods wanes. Craft specialist villages developed and, therefore, individuals associated with those crafts were no longer unique as many in the village produced the goods. This appears to occur in the Mid Iron Age where very few people have industrial goods buried with them. Noen U-Loke, however, only contains industrial goods relating to textile production. Does this suggest that the village was essentially a textile weaving village?

There is a high percentage of pottery in burials in the Bronze Age. At this time pottery production was a non-specialised task that each family would have laboured at, whereas as villages became more complex, craft specialization occurred and pottery production was completed by a restricted number of craftspeople and therefore the pots had to be purchased. Pottery in the burials of Noen U-Loke are made of high quality ceramics (Higham, 2002). O'Reilly (2001) suggested that these pots were made in other pottery centres and not locally by the inhabitants of Noen U-Loke. This is due to the scarcity of ceramic anvils used in the pottery industry found at Noen U-Loke. The pottery anvils are found in the earliest phases of the Iron Age, which shows a period of transition from village production to specialised centres elsewhere (Voelker, 2007).

At Ban Non Wat, males had goods relating to pottery and textile production as did the females, and whilst metal production goods are dominated by males, one female in the Late Bronze Age had an axe mould made from clay as well as items relating to pottery and textile production. It could be suggested that she was multi skilled as required in a village where crafts were not specialized at the time. The clay mould may not, however, be related to metal production, but also her skill in pottery production, or perhaps did not belong to her at all, but was a symbol placed into her grave by her metal working family.

7.2.5 Establishment of a new community

Based on the radiocarbon dates (Higham and Higham, 2009), Noen U-Loke is a younger community relative to Ban Non Wat. Are there any differences between the two sites in the Early Iron Age that highlights the relative youth of Noen U-Loke? In the Iron Age there are differences between Noen U-Loke and Ban Non Wat in how ornaments are used in the burial ritual. In Noen U-Loke ornaments were customary in the burial ritual, whereas in the neighbouring village of Ban Non Wat, the use of ornaments in burials was not and possibly relates to the social identity of the person. The lack of customary use of ornaments in Iron Age Ban Non Wat may suggest that the societal structure is different to that of Noen U-Loke. Ban Non Wat has had a longer period of development as a society, it has been occupied since the Neolithic whereas Noen U-Loke has no evidence of a long occupation. Its beginnings are at the end of the Late Bronze Age and compared to Ban Non Wat it is a relatively new village. The dynamics within each society are likely to have been different as a result of this. Communities, such as Ban Non Wat, would have had established societal processes, whereas a new community would be still finding its way. Could the ornaments in the graves of Ban Non Wat be related to wealth, identity, roles or familial ties? Are ornaments more readily available at Noen U-Loke compared with Ban Non Wat?

The prevalence of pottery in the burial record may provide an indication of the phase during which a community is being established, as well as whether or not it is the customary burial ritual of the period. At Noen U-Loke in the Early Iron Age there are few burials that were interred with pottery. In a community that is being established, the production of goods at a familial or community level would be important. The goods produced would be focused on daily use rather than for burial ritual. As craft specialisation occurs within a community, goods become more prevalent and diverse and trade with craft centres could occur. Pottery made for burial ritual, as opposed to domestic pottery, would have been more common. With the ability to produce or purchase ritual pottery, the custom of the community to bury their dead with pottery becomes common and it is more unusual not to be buried with pottery, as seen in the Mid Iron Age.

The Early Iron Age is the only comparable phase between Noen U-Loke and Ban Non Wat. A considerably larger percentage of burials at Ban Non Wat contain pottery at this time. Perhaps in the early stages of the establishment of Noen U-Loke as a society pottery is not placed within burials where the family did not have plentiful pottery supplies. Although craft specialization was taking place, the higher percentage of pottery in the Mid Iron Age does not support this conclusion. However, the Mid Iron Age may show a change in burial ritual. Whereas the Bronze Age is characterized by the placement of whole pots in graves, many Iron Age burials were covered in what appear to be deliberately broken pottery sherds. The increase in pottery burials from the Mid Iron Age may be related to a change in ritual habits of the village.

Few females in the Early Iron Age in Noen U-Loke had pottery interred with them, but by the Mid Iron Age, the majority of females had pottery. Comparison with Ban Non Wat in the Earlu Iron Age shows a relatively high proportion of females with pottery (Table 58). At Ban Non Wat, in Iron Age burials, it was noted that some burials contained ritually broken pottery, that is, the pottery is ‘killed’ over the burials. This ritual did not occur in Noen U-Loke. What was occurring in Noen U-Loke that discouraged the deposition of pottery in female burials? Perhaps the Early Iron Age was the period when Noen U-Loke was developing as a community. The pottery made at the village was considered too valuable to be placed within the grave. Perhaps craft specialization had yet to begin in the village and there were difficulties in establishing an agricultural society as well as maintaining the production of domestic or even ritualistic goods.

7.2.6 Change in customs

Change in burial customs is evident from the Mid Bronze Age to the Mid Iron Age. One example is the interment of animal bone in burials. The presence of animal bone in burials is not reliant on production capabilities, although it is reliant on the presence of animals in the community. Within the sites of Noen U-Loke and Ban Non Wat, the symbolic nature of animal bone appears to change over time. It is not common for burials to contain animal bones in the Bronze Age, and where they are found they are mainly confined to male, mid adult burials. This may be related to the importance of the male individuals regarding their animal husbandry responsibilities or that the bone signified a specific symbolic meaning. There was a sharp increase in animal bone in burials in the Early Iron Age. This suggests that the significance of the symbology of animals is at its peak at this time, or that animal husbandry was common and the presence of animal bone in these burials related to familial ties. Females, especially had obtained the right to have animal bones in their burials, and all age groups were represented. At Noen U-Loke, approximately half of the interments were buried with animal bone in the Early Iron Age, but by the Mid Iron Age, no burials had animal bone. The significance of animal bones appears to have lessened significantly. Perhaps the intensification of rice farming in the area lessened the importance of animal husbandry in the community as animals became less symbolic and more of a source of food.

How pottery is utilised in the burial ritual changes over time. The decrease in the use of pottery at Ban Non Wat over time suggests that at one time it was common, and possibly obligatory, to place pottery in a grave. At some point in time, there was less of an obligation for pottery offerings. Unlike the pattern at Ban Non Wat, the pattern at Noen U-Loke does not suggest that social identity, such as age or influence of the individual, motivated the placement of pottery in the burial. This is particularly noticeable in the increase of pottery in young adults in the change from Early to Mid Iron Age (Table 60). The cause may not relate to the social identity of the dead person, but the social identity of the family. Mid adults are considered to have the most influential social identities, whilst young adults have the least influential. A high percentage of young adults with pottery suggests that either they were related to the pottery industry, the prosperity of the family enabled their placement, or that the ritual was, at least in part, a political or social stratagem on behalf of the family. On the other hand, in the Mid Iron Age, the placement of pottery with the dead may not have been related to social status, but part of a social 'norm'. Pottery became a standard item at burials.

7.2.7 Establishment of power subgroups

The orientation of the body at Ban Non Wat and Noen U-Loke can be interpreted in a number of ways. One of two possible interpretations deals with the east oriented females at Ban Non Wat and the north-east oriented groups at Noen U-Loke. Those buried oriented east in the Late Bronze Age and Early Iron Age at Ban Non Wat in our sample are exclusively female, whilst in the Mid Bronze Age all east oriented burials were male. It can be suggested that the females were part of a sub-group, although what this affiliation is cannot be determined.

At Noen U-Loke, there are clusters of burials that face north-east as opposed to the norm of a north-south orientation. Are these new migrants? Or, an attempt to designate a sub-group in a show of power or influence? These are only two of what must be many possibilities. The Mid Iron Age has no north-east oriented burials, suggesting either that either the new migrants conformed to the norm of north south burials in time or that by the Mid Iron age such shows of group affinity were no longer required.

An isotopic study of the Noen U-Loke sample was conducted by Cox et al. (2011). Three individuals were identified as being probable immigrants. Two of these individuals are part of the current study. They are mid adults: one female from the Early Iron Age and another female from the Mid Iron Age. The female from the Early Iron Age (NUL35) was buried in a north-east orientation. Her grave offerings included a large number of ornaments, including agate and glass beads, a bed of rice and weaving tools. There appears to be no specific difference between NUL35's and the other burials from the same time period seen in the burial goods. NUL35's only differentiation is her height. She is shorter than the other individuals in the Early Iron Age sample. The female from the Mid Iron Age (NUL110) has very few burial goods, comprising only a few ornaments. She is, however, the only individual in the sample with a tridacna ornament in the Mid Iron Age. Does this shell signify her immigrant status?

7.2.8 Status interpretations

Questions of gender roles are raised in relation to the presence of blades in Ban Non Wat, where more females were buried with blades than males (Table 52). Why are the women buried with blades? Does this suggest that the blades buried at Ban Non Wat can be identified as domestic tools? Can they be associated with gender roles? Did these blades have some meaning to these women or did the family members associate the individual blades with their owners and as a result place the blades in the grave rather than keep them for further use? One female was buried with bronze arrows, whilst the female from the Early Iron age was buried with socketed iron blades. The two burials suggest different burial rituals, one based on the placement of utilitarian iron blade tools and the other on possibly more symbolic bronze arrow heads. There are only two females in Ban Non Wat that were buried with blades, so more data are needed to further evaluate gender roles at Ban Non Wat over time.

If we are to conclude that grave good categories that have the ability to portray prestige or desirable status are ornaments (jewellery) and 'other' (rice bed, ochre and bivalve shells) and that those with both of these goods types are of an esteemed social identity, can we see this at either site? There are no significant differences between the age groups and sexes (Figure 141 and Figure 142), but there is a trend at Ban Non Wat of young adults being buried with less ornaments and other goods over time. This agrees with the notion that in a less stratified society, there is less emphasis on 'status' items and more emphasis on family ties, and through time 'prestige' items are placed in the graves of those who have 'acquired' a group status unrelated to that of family alone. The trend for older and mid adults does not, however, justify this interpretation, nor is it applicable for Noen U-Loke. Therefore, we can conclude that ornaments and other goods are not signifiers of the 'elite'.

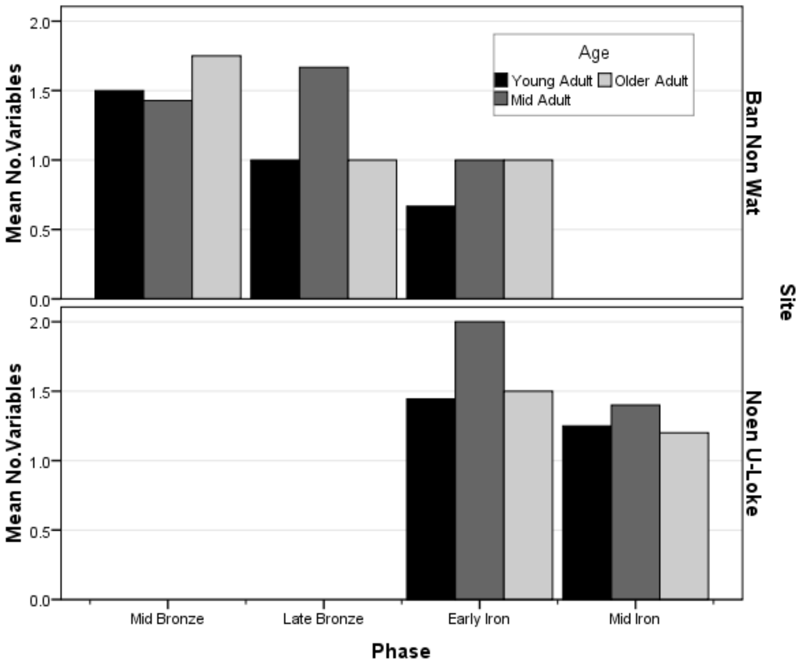

Figure 141: Mean number of variables (from ornament and 'other') according to age, phase and location.

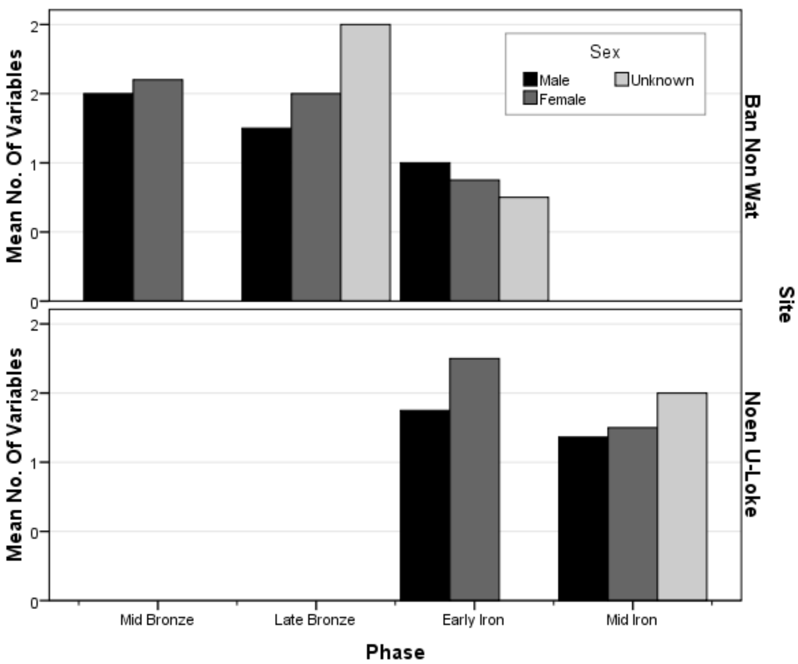

Figure 142: Mean number of variables (from ornament and 'other') according to sex, phase and location.

The reason for the placement of ‘other’ goods in burials may relate to time and place. Older adults at Ban Non Wat have the highest percentage of ‘other’ goods whilst mid adults dominate at Noen U-Loke. The presence of ‘other’ goods in the graves of older adults at Ban Non Wat may signify the respect for their contribution to the community, but in Noen U-Loke, it appears that ‘other’ goods were placed in the graves of those individuals who would have been at their productive peak and their loss would have been lamented. This suggests societal differences were inherent at Ban Non Wat and Noen U-Loke. The reasoning for this is important to identify and possibly related to the stage of establishment of a society (see Chapter 7.2.5.).

The use of ornaments to identify ‘prestige’ or social status appears to be difficult at Noen U-Loke. Every female has ornaments, so to designate the mere presence of ornamental burial goods as prestigious would be erroneous. In addition, only a few males lack ornamental goods. Talbot (2007), has distinguished two burials from Noen U-Loke that have significantly different ornamental goods. NUL4, which had signet rings, the only examples found in the site, and NUL113, which had over a third of the agate and carnelian jewellery. Agate and carnelian jewellery is considered to be prestigious, as they are not common goods. Twelve other burials are labelled as being potentially “high status” (Talbot, 2007).

Burial NUL4, who was buried with signet rings, is a young adult of unknown sex dating from the Mid Iron Age, who was not buried in a cluster. This individual had a total of nine objects, mainly jewellery. Other items include a knife, sickle and two pots. The presence of the signet rings has classed this person as ‘high status’, but as the Mid Iron Age is a phase where it appears that trade networks were strong could the signet rings actually signify ‘high status’? If they do, then the person themselves may not be ‘high status’, but they belong to a group that wishes to be perceived as “high status”. But in a phase where the average number of burial goods in a grave is 24, and one individual has 141 items, can this burial still be considered to be of ‘high status’ based on one or two items?

Burial NUL113 is a young female, again from the Mid Iron Age. The reason for the designation as ‘high status’ by Talbot (2007) is that this individual had a relatively large amount of agate beads. The question of this assessment is that are the agate beads, and therefore the assessment of status related to one object, such as a necklace or more than one piece of jewellery? The burial goods data suggests that it is one item. Again, based on one item, ‘high status’ is applied to a young adult. If this young adult had ‘high status’ then it is likely to have been attained through association with a group. This individual, however, also had bronze, silver and gold jewellery and was laid on a bed of rice. By the standards of the day, the burial contained many non-utilitarian items, many of which would have been long distance trade items. The number of items in the grave were above average (n=68). But based on this assessment a large proportion of the Mid Iron Age sample should be considered ‘high status’ due to the amount of long distant trade goods, such as agate, among the ornamental burial goods.

In order to determine social status in the Mid Iron Age, other indicators appear to be required. The burials that contain a large amount and various types of jewellery appear to also be rice burials and were interred as part of one of four clusters. These individuals represent all age groups (NUL14, NUL62, NUL69, NUL76, NUL78, NUL96, NUL98 and NUL113). It would therefore be more consistent to say that these eight individuals are part of an expression of desired or perceived status on behalf of the individual or the group that they belong to. Not all interments in the clusters have as 'rich' or 'ostentatious' burial goods, therefore these eight burials appear to be a statement of power or prestige. The rice bed is not found in non-cluster burials in the Mid Iron Age sample. All burials at Noen U-Loke that contain 'other' burial goods are buried in clusters. The non-cluster burials do not contain any bivalves, ochre or rice. This does seem to reiterate the purpose of the cluster burial: to reinforce or obtain a perceived group status. This is not considered to be a reflection of status of an individual. In Europe the change from cluster or collective burials to that of individual burials is seen by some as evidence of the introduction of social stratification, such as in Bronze Age Europe (Gilman, 1981). Wason (1994:92) states:

1. Communal burial indicates that an important aspect of status in death (and significance for the living) is being part of a social group, probably with unambiguous kin-based membership.
2. Individual burial indicates either that the group membership is not an important part of status in death, or that it is important but not marked by the practice of communal burial.
3. A change from communal to individual burial may mean a change in how social group membership is affirmed, a social change reducing the importance of marking this aspect of status, or both…. It may mean the growing assertion of the individual….over the group. The status system may be moving toward greater emphasis on personal achievement, towards social stratification, or both.

At Ban Non Wat, the burials in the Bronze Age are uniformly individualized and placed in rows. The Iron Age of Noen U-Loke is delineated by the clustering of burials. If what Gilman and Wason state is applicable, then the transition from the Bronze Age to Iron Age in Thailand signified the de-stratification of society. This appears to be unlikely as the Iron Age of Thailand leads to the emergence of empirical states. More likely it is a period of some sort of social unrest where emphasis on social groups, such as a family (extended or lineage), was required to establish or reinforce power or another ideal. Wason (1994) states that elaborate mortuary burials may be indicative of individuals or groups that are trying to establish or reinforce an elite status, whether from power, religion or hereditary. Elaboration of mortuary ritual is particularly strong when this status is threatened. Once status is widely accepted, Wason (1994) states that there is no longer a need for elaboration. The clustering of the burials, therefore, comes at a time when social upheaval was taking place. Groups of people were signifying their differences to establish the membership of military, wealth or political power or hereditary groups. The lack of elaborate burials, of which the only evidence may be the burial goods, may signify the easing of social upheaval and the acceptance of the format of society or social order. Despite all this, it could be that the orderly lines of Bronze Age burials may also be collective burials: lines that consist of family members. DNA analysis is the only way to determine familial connection between individuals and this has not been undertaken.

The pattern of spatial burial in the earliest occupation of Iron Age Noen U-Loke appears random. The burials are either of north-south or east-west orientation and are not clustered, but two burials do lie next to each other. There are few burials in this stage and it is unclear if this is truly representative of this phase. The end of the Early Iron Age is a period where clustering is evident. All burials are in one of two clusters that are orientated north-east. These are likely to be lineage groups. Talbot (2007) suggests that a structure, such as a mortuary building, may have been built above the graves, which explains the clustering of interments in a confined area. The beginning of the Mid Iron Age also sees defined clusters of burials, but these are less confined than Early Iron Age clusters. They are on a north-south orientation. There are also a couple burials adjacent to the clusters that are perpendicular to the clusters. They are not likely to be related to the clusters. Later in the Mid Iron Age, there are moves away from clustering once again. The burials are randomly placed and on a roughly north-south orientation. There is some superimposition of a few burials, which may be accidental or a continuation of lineage cluster burying.

Determining if there are any differences between clusters at Noen U-Loke in the various phases is not possible as not all burials in each cluster were included in the health index due to poor skeletal information, therefore the sample is much smaller if broken up into such small groups and is not a viable indicator.

8 RELATIONSHIPS BETWEEN HEALTH AND STATUS

8.1 Stress, Social Inequality and Health

This sub-chapter discusses the impact of non-medical issues on health. This includes societal factors and the stressors associated with them. Stress manifests in humans either physiologically or psychologically. It can be defined as "a measurable psychological disruption or perturbation that has consequence for individuals and populations" (Goodman and Martin, 2002: 12). There is some debate on the use of the word 'stress' due to "its generic nature in defining the problems affecting a population" (Domett, 2001: 7), But other terms also do not adequately describe the effects of stressors; therefore in this review, it will be used generically.

Stress, state Goodman et al. (1988) depends on a number of factors, including genetic susceptibility, age, sex and resiliency. They demonstrate that there is a cyclical relationship between the environment and stress (Figure 143). The environment is a source of stress and part of the solution required for survival.

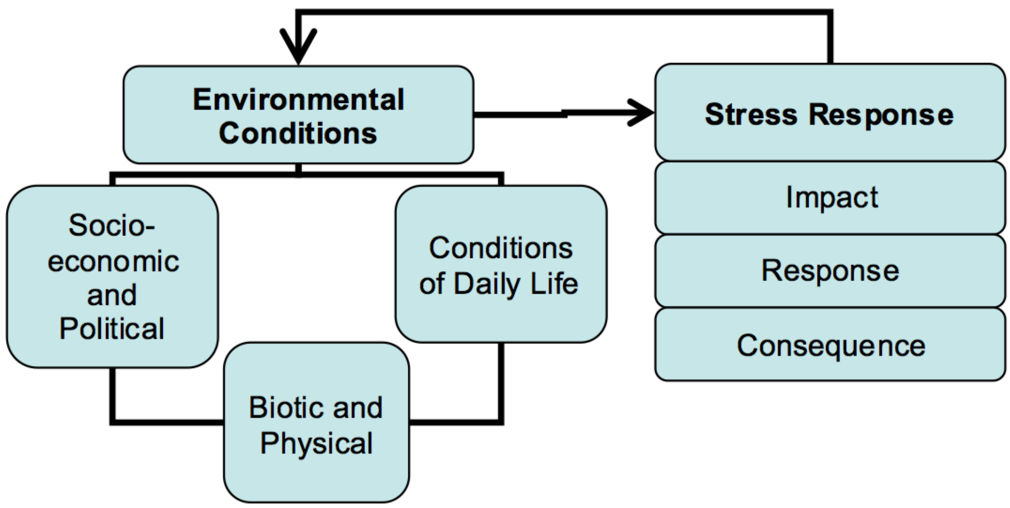

Figure 143: Cyclical relationship between environmental conditions and stress response (from Goodman et al. 1988).

A stress model was devised by Goodman and Armelagos (1989) relating to archaeological sites (Figure 144), based on Selye's theory of stress response. Cultural resources can buffer environmental stresses. They can be provided by sectors of society in times of need, but this may also engender new threats to the population. When cultural buffering is not adequate there is a physiological response to the stressors. If that physiological response is not sufficient to handle the stress, the population is placed at risk. Socio-economic factors not only generate stress, but also intensify those already present; for example, there may be restriction of access to other resources by a sub-sector (Goodman et al., 1988). Other examples of cultural buffering include technological advances and extended trade networks. Technological advances do not necessarily provide a buffer for stressors and they may introduce new stressors into a society. For example, the 18th century industrial revolution in Europe introduced an enormous amount of stressors into the population (Deane, 1979, Wrigley, 1988). Technological advances could be found in the mining industry, metallurgy, textiles and a multitude of other areas. The resulting social change saw a build up of urban populations, increased pathogenic transfer, placed a strain on food supply, which resulted in subsequent malnutrition for a large portion of the population. Technological advances effectively inhibited cultural buffers. However, medical advances and progression in the academic study of social studies assisted in the buffering of the effects of these new technologies (Easterlin, 1995).

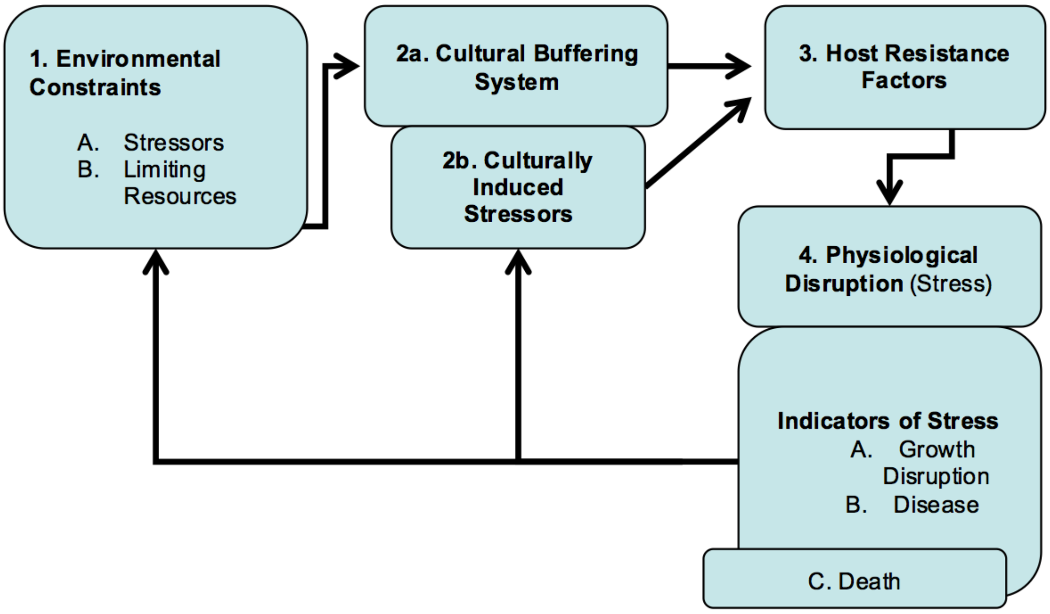

Figure 144: Stress model (Goodman and Armelagos, 1989).

A form of cultural buffering may result from social networks. There are three accepted theories regarding inequality and its effect on health. The first is social cohesion, which hypothesizes that dense social networks should equate with better health (Nguyen and Peschard, 2003). Anthropologists dismiss this theory as it 'lacks analytical clarity' and could lead to a circular reasoning (Lynch et al., 1997, Nguyen and Peschard, 2003:452). It is difficult to analyse these social factors as they are perceived as being conceptual. An example given by Nguyen and Peschard (2003: 452). is "Societies are healthy because they are trusting, and there is a lot of trust because societies are healthy"

The second theory is neomaterialist: that material factors effect health. Deprivation of material goods, infrastructure and services may compromise health (Nguyen and Peschard, 2003). A study by Lynch et al. (1994) found that socioeconomic status during childhood impacted the health and wellbeing of the adult. Despite this, modern studies show that there is a relationship between poverty and ill health. A study of modern civil servants have identified a 'hierarchy effect' where rank within an organisation appeared to be the sole factor that affected life-expectancy (Marmot, 1986). This is also called the 'Gradient Effect' and studies suggest that of two individuals with the same income, one in an egalitarian and the other in a more hierarchical society, the individual in the egalitarian society will be healthier (Wilkinson, 1996).

In archaeological skeletal collections, Goodman et al. (1988) state that by looking at socio-economic factors and unequal access to resources, the sub-groups with the highest levels of insults, medical conditions or injuries, are most visible. They state that these groups may undergo 'perceived' stress, which is psychological. That is, these people know what resources they need to sustain them, but cannot obtain them and therefore they have a strong belief that they have lost control. This can occur at a household or community level. This equates to the third theory regarding inequality and its effect on health; that is, that health is impacted by psychosocial factors engendered by inequality (Nguyen and Peschard, 2003).

Whilst inequality and stress has a demonstrable impact on modern populations, these have also been identified in archaeological studies. Stress is dependent on cultural factors, which will be discussed in the following chapters.

8.2 Health and social status studies

In archaeology it is difficult to understand the standard of living at an individual level simply by looking at the burial goods found with the interred (Robb et al., 2001). Although modern studies (Nguyen and Peschard, 2003) have shown that low status normally equates to poor health, investigations of ancient societies have not shown this. Various studies of pre-modern populations had shown that whilst in some instances being wealthier may result in a healthier life (Robb et al., 2001, Mayes and Barber, 2008), in others similar health levels are found in low and high status individuals (Wilkinson and Norelli, 1981, Powell, 1986, Powell, 1992) and others show conflicting results (Schepartz et al., 2009). Health status not withstanding, social status is generally based on the 'richness' of the burial goods. There may be multiple social factors and complexity in each burial. Pechenkina and Delgado (2006) state that social status is not static throughout an individual's life. Therefore, recent studies have endeavoured to look at burials in a more holistic way, which includes looking at the health of the individual as well as the burial goods. This chapter highlights a number of different studies and the methodologies used.

Shimada et al. (2004) state that to understand social and biological status and their implications, several requirements of an investigation are needed:

- Research should not be confined to sites, but regionally based. Such as the work done on Mississippian cemeteries (Milner, 1984).
- Burials, their rituals, settlements and also places associated with rituals or ceremonies should be studied.
- Samples should be large and diverse. They should include a good representation of the regional population.
- There should be a balanced study of multivariate factors, including non-biological factors.

Numerous studies focus their health interpretation on a small number of health indicators (Wilkinson and Norelli, 1981, Jankauskas, 2003, Schweich and Knusel, 2003, Maat, 2005). For example, one investigation looked at the relationship between caries and ante-mortem tooth loss and social status in a Maya population at a period when social stratification was evident (Cucina and Tiesler, 2003). In this small sample of 49 adults, low or elite status was determined by a scoring system based on status markers, which involved the placing, quality and quantity of grave goods. Those with no status markers received a score of zero, whilst those with more than six status markers scored five points. Those with a score of zero or one were considered to be of low status and those from two to five were considered elite. Correlation between caries and ante-mortem tooth loss and status, showed that the elite were not healthier than the low status individuals. There were also differences between the males and females of the elite, with the women having more caries, possibly due to female elite having a more cariogenic diet than the male elite. Physiological and hormonal differences between males and females may have also accounted for the differences in caries rates (Lukacs and Largaespada, 2006). It would be interesting to see if, had other pathological indicators been used, what the assessment of health of these two groups would indicate.

Status estimations have been subjective in a number of archaeological studies. For example, Shimada et al. (2004) interpreted status of interments on a case-by-case basis. A juvenile was considered to be of some importance despite having no grave goods. The position of the body near the primary elite burial determined the status of the individual. This assessment of status is open to alternative interpretations. Another instance of problematic status interpretation is found in Jankaukas' (2003) study of the relationship between Foresters Disease (or Diffuse Idiopathic Skeletal Hyperostosis) and social status. Social status was determined either by burial location, or the number and quality of grave goods. It is unusual for status to be determined in entirely different ways and one would imagine that these could not be comparable. Without detailed knowledge of the cultural groups, it is difficult to see how status could be determined by location alone.

Some studies utilize an adequate number of health indicators, which can accurately interpret the health of populations, but have ambiguous status assessments. A subjective study was conducted by Pechenkina and Delgado (2006). Using a small sample, multidimensional scaling of the health indicators were utilized to investigate patterns of variation. Their relevance to social structure was then investigated, as indicated by the grave goods. Social status was determined on a scale based on the number and type of grave goods (0 for no non-perishable goods; 1 for common objects; 2 for at least one rare artefact; and 3 for burials with rare objects from more than one type). Their findings suggest that there is a social effect on the health of this population, especially that of males. Status is dependant on the rarity of artefacts in this study (Pechenkina and Delgado, 2006). Detailed knowledge of each burial good type is needed to determine why that particular object would be rare. For example, a burial may contain a common domestic vessel, whilst the others contain specially manufactured burial vessels. The burial with the domestic vessel is, in this methodology, designated a higher status as that type of vessel is rare, even though the vessel is domestically common. Unless it is known that the vessel is common (outside of the mortuary context), status determination could be erroneous.

An ideal methodology for status interpretation involves the use of enthnohistorical data. For example, Gamble et al. (2001) investigated social and health status of a prehistoric Amerindian population through the use of a wide range of data types, including skeletal data, burial foods and ethnographic and historic sources. They compared data from a relevant historical cemetery with ethnohistorical data, then used this to see if there were any similarities with the prehistoric burials. This is an interesting way of interpreting prehistoric data, but is not possible for the present study. The main difference between the study by Gamble et al. (2001) and the current study of Southeast Asia is that they had easy access to detailed ethnographic information whereas there is no such data available for Southeast Asia. They did, however, utilize a simple system of testing status by looking at status through the presence of items known to be a wealth items. This method could be used in the present study if such an items could be identified.

8.2.1 Holistic study

The breakthrough paper by Robb et al. (2001) demonstrated the usefulness of holistic studies. As it is an important paper and relevant to the present study, it will be discussed in some detail. Robb et al. (2001) investigated the relationship between social ’status’ and biological or health ‘status’ in Iron Age sites in Italy. The authors wanted to determine if there is a relationship between skeletal health and funerary treatment and to see how the data obtained from both areas, looked at jointly, could be more useful than if analysed separately.

The sample used by Robb et al. (2001) is thought to represent the population, except for the most elite and the poorest. Burial treatments range from simple pit graves with no goods to complex tombs with numerous and exotic goods. The data collected on each skeleton include age, sex, pathological and activity related data and grave goods (see Table 88).

Table 88: Data collected by Robb et al. (2001).

SKELETAL DATA	GRAVE GOODS DATA
Age	Total items per burial
Sex	Total ceramic vessels per burial
Stature	Total items other than ceramic vessels per burial
Enamel Hypoplasia	Total ornaments per burial
Cribra orbitalia	Total items of weapons/armour per burial (males)
Trauma	
Tibial periostitis	
Schmorl's Nodes	

A small component of the study investigated variations in health within sub-groups of the male interments, which were identified by comparing the following variations:

- 'no grave goods' versus 'grave goods'; and
- 'no grave goods' versus 'grave goods but no weapons' versus 'grave goods with weapons'.

They found inverse relationships with many of the biological and grave goods variables. One of these is between trauma and weapons, Robb et al. (2001) suggest that maybe the weapons are symbolic rather than evidence of warfare. Males with weapons had no pathologies, which suggest a better quality of life and minimal physical stress. It was also found that men with low amounts of grave goods were likely to suffer from trauma, periostitis and Schmorl's nodes. The age of the individuals was not included in the interpretation, which is considered to be an oversight.

Robb et al. (2001: 220) came to three conclusions:

1. There is no direct relationship between social and health status in their study sample. This suggests that either the sensitivity of the biological indicators is not fine enough to pick up differences; that having wealth did not necessarily protect from disease; or that the nutrition of the poor was adequate enough to overcome medical insults.
2. Some patterns were identified. The males with 'no goods' were more distinctive than others in terms of musculoskeletal stress and trauma.

3. In order to better understand the relationship between health and status, the analysis of the variables needs to be “carefully contextualised socially and historically”. That is, each area and era is different and the variables used to analyse the relationship needs to be thought out carefully.

Robb et al. (2001) states that in order to identify these relationships a hierarchical society is required and that the status of individuals must clearly be identifiable from the burial treatment. The assumptions made regarding the social status of individuals can be problematic, as Robb et al. (2001) found. The complexity of lifestyles and their impact on the individual appears to have a large influence on the result. The measures of ‘society’ are more complex than hypothesised. Building on the methodology by Robb et al (2001), other researchers have focused on the relationship of activity and social status.

Porčić and Stefanović (2009) used absence and presence of burial goods to identify status in a Early Bronze Age necropolis in Mokrin, Serbia. Status and wealth, Porčić and Stefanović (2009) postulate, are correlated. Status was calculated using a Guttman scalogram based on the presence or absence of burial good types and materials. Each individual received a wealth score, relative to sex group. No correlation could be identified between activity and status. The study did reveal issues with both health and status methodologies. They question the use of musculo-skeletal markers for young and old adults based on amount of activity undertaken in those age groups. These age groups may not be as active as those in mid adult age bracket. It is also assumed that the results of the Guttman scale will correlate to wealth and despite subsequent recalculation and standardisation, the link between the Guttman Scale and wealth is not clear. The assumption is that wealth equates to quantity and quality of burial goods, but how quality is measured is not stated.

From cemetery samples dating from the Late Archaic Period in Ohio, Woo and Sciulli (2013) used presence or absence of burial goods to calculate scores to indicate status and investigated correlations with activity stress markers. The types of burial goods, such as ornaments or pottery are not differentiated, except for ochre. The ‘quality’ of burial goods is the main measure. However, this measure defines goods as being common or rare. The score obtained is then compared with degenerative joint disease in the sample. No relationships between status and health were found. They infer that the social status measure indicates wealth, but the assumption is that rarity of goods equates to wealth.

Using a medieval Moravian sample, Havelková et al. (2013) applied factor analysis to the absence or presence of specific goods, such as spindle whorls and razors, as well as some contextual information, including burial depth. Musculo-skeletal stress markers or entheseal changes (EC) were used to identify activity. Relationships were found between musculoskeletal stress, related to the triceps brachii and gluteus medius, and males buried in deep graves who had implements associated with the warrior class. Commonly found goods and shallow graves were associated with males with wrist stress markers. Those with warrior goods are considered to be of higher socioeconomic status than those with only common goods. No differences were found in the female sample, suggesting that there was little variation in activities that would produce entheseal changes, within the female population. Their findings do not confirm that there is a positive correlation between musculo-skeletal stress markers and socio-economic status, but they do illustrate that status is complex. Occupation is only a component of status, and a correlation between activity and status requires numerous assumptions.

Whilst the hypothesis that Robb et al. (2001) was testing related to 'elites' and 'commoners', their basic methodology can be used to identify more complex relationships between health and social status. Assignations of wealth status or a hierarchical society are not required. Robb et al. (2001) used multiple variables in the investigation of status that would be useful in the present study. Instead of manipulating the burial goods and contextual data into a status score as undertaken by Porčić and Stefanović (2009) and Woo and Sciulli (2013), a robust first undertaking is to identify any associations based on simple correlations. Rather than assigning wealth to each individual, a variety of burial treatments and goods at simple levels can be used in correlation analyses. No assumptions of status are made and the results can be examined to identify patterns. From the results of a wide ranging analysis, it may be possible to identify social identity.

8.2.2 Heath and status in the present study

Status identification is not self-evident in the examination of a burial. In the present study, in order to look at society, some of the methods employed by Robb et al. (2001) appear to be the most appropriate to be used. This involves separating interments by burial goods type (see Chapter 6.3.1). For example:

- burials with ceramic vessels;
- burials with ceramic vessels and personal ornaments; or
- burials with ornaments, but no ceramic vessels.

This does not imply a set status level or wealth, simply burial treatment alone. Instead of looking at health within each 'status' group, burial treatment will be placed into health groups.

The methodology used in this study, combining health attributes with burial treatments, differs from most previous studies. The majority of studies, whilst acknowledging difficulties in assigning wealth or status, calculate status and as a result may be erroneous and unverifiable.

Using burial treatments as indicators of social status can provide valuable information without assigning a numerical wealth estimate to an individual. The inclusion of health status with that of social status provides a new and holistic view of ‘status’ and the life-style of the individual and the society itself.

Statistical analysis as well as examination of the data can be used to assess health and society in this study. The following sub-chapter contains a correlation analysis between the SEAHI assessment and burial good factors. Following is an examination of a number of individuals to show the capability of the SEAHI and burial good data.

8.3 *Health and Burial Treatment at Noen U-Loke and Ban Non Wat*

8.3.1 Significant Statistical Relationships

In order to identify relationships between health and burial treatments, a number of statistical methods were used. Independent samples t-tests, one-way ANOVA and correlation calculations were conducted to test if there are any significant differences in health and burial treatments. The combinations used are not exhaustive.

8.3.1.1 Ban Non Wat and Noen U-Loke

There are statistical differences in health between those with animal bone, who are unhealthier than those without animal bone (Table A 32 [p. 470] and Table A 35 [p. 475]). Whilst most of the statistical relationships seen here and below in other sub-groups appears to show having a specific burial good type as being 'unhealthy', it has been found that those that have blades are statistically healthier than those who do not have blades (Table A 32 [p. 470] and Table A 36 [p. 476]). What does this suggest? We can assume that those people whose occupations involved the use of blades were healthy. Problematic to this assumption is that the exact nature of each blade needs to be determined. Whether or not it was a blade that was used for a task or essentially ornamental. Could we legitimately compare blades over time when blades are not common in all time periods? In this study blades are uncommon in the Bronze Age. It would be difficult to compare the health of the individuals with blades in the Bronze Age with those in the Iron Age.

There is also a statistical difference between those who have ornaments, pots and 'other' goods and those who do not have all of these three burial good types (Table A 32 [p. 470] and Table A 37 [p. 477]). Those with these types are significantly less healthy than others. Another statistical relationship can be seen in those with ornaments and animal bones, those with animal bones and pots, and also those with animal bones and 'other' goods in their graves (Table A 32 [p. 470], Table A 38 [p. 478], Table A 39 [p. 479] and Table A 40 [p. 480]). They are significantly less healthy than those people that do not have both types of burial goods. This result may be influenced by the animal bone (alone) result above.

The orientation of the burial also appears to be significant (Table A 33 [p. 472] and Table A 41 [p. 481]). East oriented burials are significantly unhealthier than south oriented burials, who are the healthiest ($t[31]=-4.089$, $p<0.05$). The majority of burials oriented south are from the Iron Age in both sites, whilst east oriented burials can be found in each phase at both sites. In the case of three of the east oriented burials from Ban Non Wat (BNW210, BNW215 and BNW218), there was a significant childhood growth disturbance, and in the others there were varying degrees of pathological lesions and trauma. The east oriented burials from Noen U-Loke include an individual suffering from leprosy (NUL107) and two people who may have had mobility issues (NUL108 and NUL27). Perhaps, to be buried oriented east is indicative of an unhealthy person, although not all unhealthy people are buried oriented east.

8.3.1.2 Noen U-Loke

At Noen U-Loke there are a number of statistically significant differences in health according to burial treatment (Table A 32 [p. 470] and Table A 33 [p. 472]). Those with animal bone are less healthy than those without animal bone (Table A 52 [p. 492]). Burials with ornaments and animals, or animal and other goods, or animal and pots in their graves are also less healthy than those who do not have both these goods combinations (Table A 54 [p. 494], Table A 55 [p. 495] and Table A 56 [p. 496]). The results are likely to be influenced by the presence of animal bones rather than any combination.

The interments that are buried orientated to the east are significantly less healthy than those buried in a north or south orientation (Table A 53 [p. 492]). Burials that are orientated east appear to be related to those that could be infirm in some way:

- NUL27 is a mid-aged male with fused lumbar vertebrae.
- NUL107 is a young man with leprosy
- NUL108 is an old woman with severe DJD and a fractured vertebrae
- N94 is an elderly male with a systemic disease
- NUL110 is an elderly female

Three of these individuals have animal bone therefore concerns that low scores are solely related to animal bone are not valid. This suggests that burying the dead oriented east may be related to the health of an individual. The eastern direction may have had some religious meaning. Perhaps an eastern burial was thought to remove disease from the village. There are a number of examples in anthropological literature where there has been differential burial treatment. For example in West Africa, there are three types of burial customs recorded of the Lodagaa people (Goody, 2004). How they were buried depended on the deceased, their role in the family, age and also the cause of death. People who died of an epidemic were placed in ‘trench burials’ in a stream bed, which when in flood would ‘cleanse’ the dead. A study of Early Anglo-Saxon burials found that amputees were predominantly buried oriented west-east (Reynolds, 2009). The cause of death in the Shüpfomei Naga Tribe determined how the dead were disposed (Nepuni, 2010). Individuals considered deviant were not buried in the village, but were buried outside the village. Deviant individuals were those who died by fire, drowning, childbirth, warfare, suicide or animal attack. These people were purported to be bad omens.

8.3.1.3 Ban Non Wat

There are a number of statistical relationships based on the Ban Non Wat sample (Table A 32 [p. 470] and Table A 33 [p. 472]). At Ban Non Wat, burials with no ornaments are statistically significantly healthier than those who have ornaments; as are those who have neither ornaments or pots, or ornaments and other goods, or, finally, are bereft of all three categories - ornaments, pots and other goods (Table A 62 [p. 502], Table A 63 [p. 503], Table A 64 [p. 504] and Table A 65 [p. 505]).

As at Noen U-Loke, there is a relationship between health and orientation of burial. Health of those oriented south is statistically significantly different to that of the north and east (Table A 66 [p. 506]). There does not appear to be any distinctive health issue, such as pathology apparent in these burials. Those buried oriented to the south were mainly buried with animal bones and pottery. Ornaments are not common in south oriented burials.

8.3.1.4 Males – overall

In the entire male sample, there is a significant difference in the health of males with animal bone as opposed to those without (Table A 32 [p. 470] and Table A 42 [p. 482]). Those with animal bone are unhealthier than those without. No individual only has animal bone and other burial good types, such as ornaments were also placed in these graves. This is similar to the relationship of those with pottery. Males with pottery are statistically unhealthier than those without pottery (Table A 32 [p. 470] and Table A 43 [p. 483]). In addition, males who have both animal bones and ornaments are significantly unhealthier than those males without both of these (Table A 32 [p. 470] and Table A 44 [p. 484]). The same can be said for those with animal bones and ‘other’ goods (Table A 32 [p. 470] and Table A 45 [p. 485]), as well as animal bones and pots (Table A 32 [p. 470] and Table A 46 [p. 486]). The obvious conclusion here is that males with animal bone are influencing these results.

8.3.1.5 Females – Overall

There is a statistical difference in the health of females depending on how many burial good types they have (Table A 33 [p. 472]). Those with three burial good types are statistically different to those with one and four burial goods (Table A 48 [p. 488] and Table A 49 [p. 489]). There is a general increase in health as the variety of burial goods increases until four burial good types were placed in the grave. A closer examination of the data reveals only two individuals with five or six burial good types (Table A 31 [p. 467]). Even if those two individuals are removed from the sample, the relationship remains ($F[3,27]=3.861$, $p<0.05$). Although this pattern is seen in females in both sites, it is only statistically significant in Noen U-Loke ($F[3,12]=4.57$, $p<0.05$) (Ban Non Wat ($F[3,11]=0.45$, $p>0.05$). This is further examined below in Chapter 8.3.1.7.

Other statistical differences are seen in the presence of both ornaments and ‘other’ goods, as well as those with ornaments, pots and 'other' goods (Table A 32 [p. 470], Table A 50 [p. 490], and Table A 51 [p. 491]). Those with both these goods are unhealthier than those without these burial goods groupings.

8.3.1.6 Females at Ban Non Wat

At Ban Non Wat, females who are buried with ornaments have significantly poorer health than those who were not buried with ornaments (Table A 32 [p. 470] and Table A 68 [p. 508]). There were also significant differences between females at Ban Non Wat buried with ornaments and pots and those who were not buried with ornaments and pots (Table A 32 [p. 470] and Table A 69 [p. 509]). Those with ornaments and pots were significantly less healthy than those without, although this is not surprising as all but one of the females with ornaments had pottery, therefore this is related more to ornaments. There is also a significant difference between Ban Non Wat females with ornaments and industrial goods compared with those without as well as ornaments and other goods (Table A 32 [p. 470], Table A 70 [p. 510] and Table A 71 [p. 511]). When ornaments are grouped with pots and other goods, we still see a statistical difference in health (Table A 32 [p. 470] and Table A 72 [p. 512]). The addition of industrial goods also sees a difference in health (Table A 73 [p. 513]).

In addition, there is a correlation between the health of females at Ban Non Wat and the number of ornaments that they were buried with (Table A 74 [p. 515]). The lower the SEAHI score, the higher the likelihood of having more ornaments.

8.3.1.7 Females at Noen U-Loke

There is a statistically significant difference in the female sample of Noen U-Loke in relation to the number of burial good types (Table A 33 [p. 472] and Table A 61 [p. 501]). This difference is seen between those with one burial good type and those with three burial good types. The range of SEAHI scores for Noen U-Loke females with three burial good types (mean = 53.18, s.d. 2.75) are relatively tightly clustered, whereas there is a wider range around those with one burial good type (mean = 45.37, s.d. 6.11) this suggests that poorer health is related to those with fewer burial goods. There is only one type of burial good found with females with only one burial good type, these are 'ornaments'.

8.3.1.8 Males at Ban Non Wat

The males with industrial goods as well as 'other' goods were less healthy than males at Ban Non Wat who have both those burial good types (Table A 32 [p. 470] and Table A 67 [p. 507]). Three of these males were buried in the Mid Iron Age, and were either mid or older adults. The burial from the Early Iron Age was a young male. Industrial goods in graves are not as common in the Mid Bronze Age as they are in later periods. It has been suggested in Chapter 7.1.5 that these males, who would have been metal workers based on their goods, were highly regarded by the Ban Non Wat community. The poor health that they suffered over a lifetime may be related to their metalworking lifestyle.

8.3.1.9 Males at Noen U-Loke

There is a statistical difference in health between males at Noen U-Loke that have animal bone and those who do not have animal bone (Table A 32 [p. 470] and Table A 57 [p. 497]). Those with animal bone were unhealthier. All of these males belong to the Early Iron Age and had all suffered pathological lesions, two of which had signs of leprosy, and most had signs of trauma. Again an individual with indications of leprosy was of below average height. This suggests that the use of bone had little to do with the tasks of the individual, such as a hunter or herdsman, and more to do with illness in the Early Iron Age of Noen U-Loke. This result is also seen in males that have animal and ornaments, animal and ‘other’ goods, as well as animal and pots, which appears to be influenced more by the presence of animal bone than any combination (Table A 58 [p. 498], Table A 59 [p. 499] and Table A 60 [p. 500]).

8.3.1.10 Mid Bronze Age

There is a statistically significant difference in health depending on how many burial good types an individual had received in the Mid Bronze Age (Table A 33 [p. 472] and Table A 75 [p. 516]). The less burial good types one had the healthier they were. In addition those individuals who had both animal and industrial goods were unhealthy compared to people who did not have both goods types (Table A 32 [p. 470] and Table A 76 [p. 517]).

8.3.1.11 Late Bronze Age

There are no statistically significant relationships between any burial treatments in the Late Bronze Age.

8.3.1.12 Early Iron Age

There are statistical differences in health of interments depending on the orientation of the body in the Early Iron Age (Table A 33 [p. 472] and Table A 77 [p. 519]). East oriented burials were the unhealthiest, whilst those oriented south were the healthiest. Three of those that face east can be found in Noen U-Loke and each one of them showed some signs of trauma or disease. NUL107 is a young man with leprosy, NUL108 is an old woman with severe DJD and a fractured vertebrae, and lastly NUL27 is a mid-aged male with fused lumbar vertebrae. These individuals may not have been great contributors to the community at the time of their death. Were they villagers who lived on the edge of their society? Does the orientation of the body reflect this?

Another significant health difference can be seen between those who have both ornaments and pots and those who do not (Table A 32 [p. 470] and Table A 78 [p. 520]). Those with both ornaments and pots are significantly unhealthier than those without both of those goods. This is also found in those who have the three burial good types: ornaments, pots and other goods (Table A 32 [p. 470] and Table A 79 [p. 521]).

Ban Non Wat – Early Iron Age

There are no statistically significant relationships between any burial treatments in the Early Iron Age at Ban Non Wat.

Noen U-Loke – Early Iron Age

There is a statistically significant difference between those that had pottery and those who do not (Table A 32 [p. 470] and Table A 80 [p. 522]). Those with pottery were unhealthier. This is also seen in those with both ornaments and pots, 'other' goods and pots, and animal bones and pots (Table A 32 [p. 470], Table A 81 [p. 523], Table A 82 [p. 524] and Table A 83 [p. 525]). There is also a statistically significant difference between those buried oriented east and those oriented north-east (Table A 33 [p. 472] and Table A 85 [p. 527]). Do they represent different people? Are the north-east burials an incoming group or vice versa? Or is it simply that those that contributed the least to the community – the unhealthy – were deliberately placed in graves oriented east as part of a specific ritual.

8.3.1.13 Mid Iron Age

There are no statistically significant relationships between any burial treatments in the Mid Iron Age.

8.3.2 Protect the village or better health in the afterlife?

There are significant relationships between the presence of ornaments, especially in the female sample of Ban Non Wat, and poor health. At Noen U-Loke, females buried with only one burial good type were also significantly less healthy than those with more types. All of these females only have ornaments. There appears to be a relationship between female health and that of ornament placement at both sites. This suggests that the placement of ornaments in female graves may be linked to intangible factors. These may include amulets to protect the village inhabitants from ill heath or to protect the deceased as they continue onto another journey. We cannot know what the beliefs of the inhabitants were and can only suggest possibilities that can be found in modern ethnographic studies. In the Iron Age of the Mediterranean, amber was an increasingly difficult material to obtain, but it could be found as burial goods. Small, carved amber figurines are restricted to female burials (Causey, 2012). These are mainly animal figures, but the majority of burials contain a water bird. Waterbirds, such as duck were symbolically identified as guardians and connected to 'other worlds'. Their presence in a grave has been interpreted as being an amulet to assist the deceased to these other worlds.

The placement of goods for the afterlife is not uncommon in Southeast Asia. From a collective history of a village in Laos, an indication of prior mortuary ritual has been recorded. Nor Ountagok writes (in Kallen, 2004: 226)

> "The infants up to three months old were buried in jars alone, while older children were buried more like adults, with grave goods. If the living didn't supply enough materials for the afterlife, the spirit dead would haunt them in their dreams and demand that which they needed."

In some societies, jewellery assisted in protecting the living from disease and misfortune. This symbolic association can be found in Ancient Egypt (David, 2002). In some cases the wearing of metal jewellery may have assisted in preventing joint disease. It has recently been noted that wearing metal jewellery will have a profound positive effect on the progression of certain types of arthritis (Hlaing et al., 2009). Examining some of the poorest scoring individuals more closely, NUL36 scored poorly on the SEAHI. She died as a young woman and she had extensive pathological lesions, childhood growth disruptions (EH), some joint disease and below average dental health. Differential diagnosis by Tayles et al. (2007) has identified possible tuberculosis or a non-specific osteomyelitis. She was buried only with three bronze rings. On the other hand. another poor SEAHI individual, NUL108, an older female, had numerous burial goods. The ornaments she was buried with included an iron torc as well as a two iron bangles. At Ban Non Wat, the two poorest scoring individuals with ornaments were BNW218 and BNW535 from the Late Bronze Age period. Both were mid aged and had joint disease as well as non-specific pathological lesions. BNW535 was buried with two shell bangles on her left arm and BNW218 had large shell disc beads at her ankles as well as chest beads. In terms of symbology, all of the individuals had circular jewellery. Perhaps circular ornaments were symbolically important in the Late Bronze Age and Iron Age and used to protect the living and the dead from illness. The symbolic meaning of the circle differs between cultures. It is connected to the concepts of heaven, infinity, females, completion and finality, as well as good fortune (Sassoon and Gaur, 1997).

Animal bone has been found in prehistoric burials and a multitude of interpretations for its presence have been postulated. These interpretations include food offerings from funerary feasts, hunting trophies, animal sacrifice, as links to the landscape as well as symbols of social status (Reitz and Wing, 1999, Jonuks, 2005, Russell, 2011). An aspect of social identity is cuisine (Reitz and Wing, 1999). The elements of cuisine include recipes, dietary laws (who eats what and when), and these are related to social concepts of status and behaviour. For example, in some societies there are feasts where meat is eaten only by males (Lokuruka, 2006) and animals that are taboo to particular members of society (Reitz and Wing, 1999). Whether or not wild or domesticated animals are part of a meal are included in this element of social identity. Social affiliation may also be found amongst those that eat wild animals that are obtained by hunting. The animal itself, whilst being an important food, may have symbolic significance. Particular animals may have had particular symbolic associations, such as with strength, wisdom or cunning. Numerous cultures around the world have a moiety or totemic associations with animals. A modern example of a totemic society are the Kmhmu' of Laos (Simana and Preisig, 2006).

In the male sample at Noen U-Loke, there is a significant relationship between the presence of animal bone and poor health. There are a number of interpretations that can be made based on the presence of animal bone, but the relationship with poor health enables us to dismiss some potential interpretations. The presence of animal bone appears to be related to the health of the individual in some way. The symbolic association of the animal with a desired personal attribute may be the reason why these males were buried with animal bones. As an acute illness or poor health would equate with weakness, an animal associated with strength would be the most appropriate burial offering. Animal bones were placed with males with poor health in the Mid Bronze, Late Bronze and Early Iron Age. Pig is common in all phases. Wild animals in the form of deer, tiger, turtle, wild pig are seen in the Mid Bronze and Early Iron Age period as are domesticated bovids. Three males in the Early Iron Age with the poorest health in Noen U-Loke have wild animals, each has fish and at least one other wild animal. It appears that wild animals have been regarded as a symbol of strength, good health or good fortune in this time period. These males are either young or mid adults. The remaining male with poor health at Noen U-Loke is an older adult, and only has the skeleton of a young pig. This suggests that ill health of that individual was not important in the burial ritual due to his age. He had survived illnesses. Animal clay figurines of elephants, deer and cattle, were found in the Early Bronze Age burials in Ban Na Di (Higham and Kijngam, 1984b). The figurines may have embodied the qualities of the animal, and the bones also may be charged objects infused with those same qualities.

Animal amulets, whether by material or form, have been interpreted as having the ability to transfer the essence of the animal, such as strength, to the wearer (Baker, 2012). In ancient Egypt, amulets of scarab beetles were considered to imbue powers to the wearer and were buried with the deceased so that those powers could be retained for the journey into the afterlife (Andrews, 1994). Modern ethnographic examples of burial rituals where grave goods are placed to assist the after life can be found in Sarawak (Varney, 2012). The Iban people believe that there is a parallel world of the dead. Burial goods are placed so that the dead can continue their work. The majority of goods are personal belongings of the deceased.

An Akikuyu people of Africa believe that how the burial ritual is undertaken can have an impact on the living and the village (Routledge and Routledge, 1968). The Akikuyu bury only rich males and old females. They are placed in a flexed position and all ornaments that are on the deceased are removed and placed to the side in the grave. The head is oriented to the west. They believe if the head is placed to the east it will cause the death of the deceased's children. After a period of a month, in which numerous offerings and rituals are performed, the final ritual involves a prayer to protect the village.

The Hmong people venerate the spirits of their ancestors. The geomantic location of the burial within the landscape is of great important to the Hmong people and their perception of future prosperity of the living (Lee and Tapp, 2010). Similar to feng shui, having the burial positioned in the correct location is thought to bring 'good fortune' to the descendants of the deceased. A number of rituals are conducted over years relating to the 'soul' of the deceased, but it has been noted that if the family has had misfortune or illness, even years later, a ritual relating to the deceased is specifically conducted (Lee and Tapp, 2010). A bull is sacrificed and the meat offered to the 'soul' of the deceased. The Hmong believe that the dead impact the living.

Males with pottery are statistically unhealthier than those without pottery. All males in the Ban Non Wat sample were buried with pottery, therefore, is this a relationship that is conferred only to males at Noen U-Loke? Statistically, there is no significant difference between males with pottery and those without at Noen U-Loke ($t[10.777]=1.187$, $p>0.05$). The overall male relationship between health and pottery appears to be skewed by the Ban Non Wat sample and appears unlikely to be a genuine pattern. This is repeated when the Iron Age male Ban Non Wat sample is included in the t-test ($t[17.25)=1.395$, $p>0.05$).

Mortuary variability has long been used to determine social identity. O'Shea (1984) tested the relationship between mortuary variability and social identity in AmerIndian samples where ethnohistorical data was present. Social identity was clearly distinguished based on ethnohistorical data and linked with expected mortuary variables. Whilst O'Shea was able to verify a number of identities, such as an achieved rank, this was not always the case, as infants also fit into this category, which is not possible. As there is variability in mortuary goods, there is also great variability in beliefs related to the dead (Carr, 1995, Hayden, 2009). Ucko (1969:264) states that "…when the range of ethnographic activities is considered, the result is a multiplicity of possible explanations of a particular set of archaeological data…" Direct links between variability and social identity is difficult to identify as a result, and only speculation is possible.

9 INDIVIDUAL LIFE STORIES

The following sub-chapters provides examples of how individual life histories can be further elaborated by using a health index in conjunction with burial goods data.

9.1 Noen U-Loke

9.1.1 Brave hunters or symbolic medical treatment.

In the past, archaeologists have assigned identity to the dead with labels, such as ‘rich’, or ‘warrior’, based on the presence of burial goods. This is more a reflection of modern Western ideals than an actual assessment of past society. In the Early Iron Age of Noen U-Loke, there are four males that have animal bone who appear to be significantly less healthy than those that do not have animal bone. What is it about these males, besides the presence of animal bones that makes them different from the others? What do the animal bones signify? Animal bones, as burial goods, only appear in the Early Iron Age at Noen U-Loke and not in the Mid Iron Age. This could suggest that the presence of animal bone was particularly important or symbolical during this period. Talbot’s (2007) analysis of the animal burial goods at Noen U-Loke describes the pig and fish bones as ‘food offerings’ and tusks and tiger teeth as ‘amulets’. The teeth of wild animals are worn by those brave enough to hunt them. In the current study, these ‘amulets’ have been placed within the ‘ornamental’ burial goods type, whilst the ‘food offerings’ are in the (unmodified) animal bone burial goods type.

Contextually, there is a distinction between those with and those without animal bone. Those without animal bone at Noen U-Loke (n=15) are mainly young adults with few burial goods. Only two have visible skeletal pathology and none have suffered trauma. Those with animal bone have a variety of burial goods and all have suffered trauma or systemic disease. One has an endocrine disease and two have leprosy. The fourth has minor pathological lesions. The presence of animal bone may relate to the presence of illness, perhaps related to the strength of the animal and passing this onto the deceased. It may also relate to a wider complex of contributions to society. The use of the health index, however, provides additional information that can be used to interpret the lives and deaths of each individual.

All of the males in this study with any type of animal bone had ‘food offerings’ and, of these, two had ‘amulets’. These two individuals, burials NUL26 and NUL27, were buried side by side, but one individual was orientated north and the other to the south (Figure 145, Figure 146 and Figure 147). The mid-aged adult (Burial NUL27) had non-specific pathological lesions, degenerative joint disease, dental disease and vertebral trauma. His burial also contained iron spearheads and a blade that resembles a hoe (Figure 147). The other individual (Burial NUL26) was a young adult male who had an endocrine disease (hyperthyroidism, Addison's disease or congenital adrenal hyperplasia) (Tayles et al., 2007), and had already developed joint and dental disease as well as enamel hypoplasia. Red ochre was also placed in both of their graves. It could be argued, based on the presence of the 'amulets', that they were hunters. The health of the younger individual suggests that this was not the case. Some of the symptoms of an endocrine disease may have included fatigue, weakness and vomiting. The presence of the 'amulet', a pigs tusk, in the young adult's grave may have other connotations. He may have been a hunter despite illness, but the grave goods may reflect other ways he contributed to society, how much his family valued him, or how much his family was valued in the community. The burial ritual, placement of the goods with the dead, may in fact not reflect the dead, but his family and their place within their society. The tusks may be a symbol of strength, an object that he needed in the next life or afterlife, or something he lacked in life. He may have worn the amulet in life to give himself more strength. That he was buried next to an older man may mean that they were related.

Animal bones and organs have been used in medical treatments, sometimes in direct association with their symbolic powers, for millennia and continue in modern times. The use of amulets as 'medicine' is can be found in many parts of the world today. In Latin America, an amulet made from *Caiman crocodilus,* caimans, is said to be used for infection and epilepsy (Alves and Alves, 2011). An amulet made from *Bos taurus*, cow, is medicinally used for many conditions including anaemia and migraine. Both cow and caiman amulets are said to protect the wearer from snake bites. The first historical mention of the use of tigers as a medicinal source comes from a 1500 year old Chinese *materia medica* (But 1995 in Alves et al., 2013). Tiger bone appears to have been used to cure the symptoms related to infectious abscesses and ulcerated tuberculosis. In modern Thai culture, amulets play an important part of daily life. An amulet made in the shape of a tiger, from tiger or wild pigs teeth, are said to imbue the wearer with power and impenetrable defences (Srichampa, 2014). An Ancient Chinese text by Yang Xiong contains the belief that boar's tusks represent bravery (Nylan, 1993). In Ancient Greece, the boar is often found in funerary contexts. Vermeule (1979:90) states that in these scenes the boar represents "power and danger", and symbolically identifies the loser in the context of a warrior. Whilst there is no historical information regarding the belief system of the Iron Age inhabitants of Noen U-Loke, the use of the pig's tusk can hypothetically be symbolic medicine both for the living and potentially for the dead.

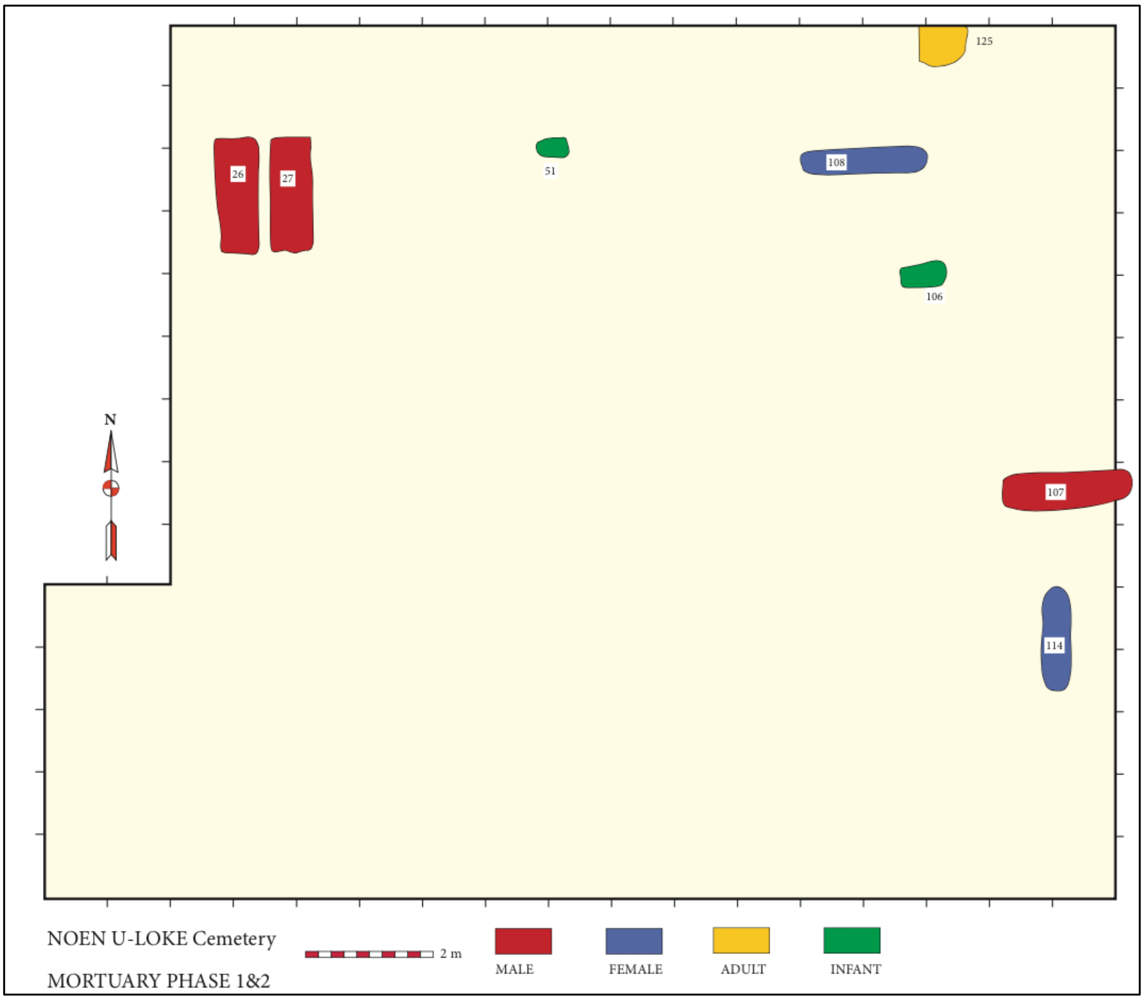

Figure 145: Plan of Noen U-Loke showing the location of the burials NUL 26 and NUL 27 (take from Higham and Thosarat, 2007a).

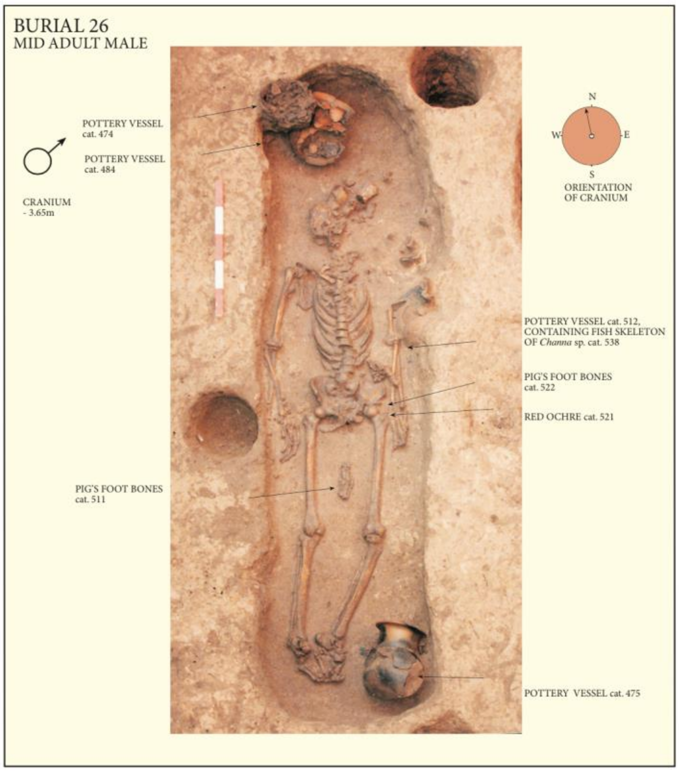

Figure 146: Location of burial goods and skeletal remains of Burial NUL 26 (take from Higham and Thosarat, 2007a).

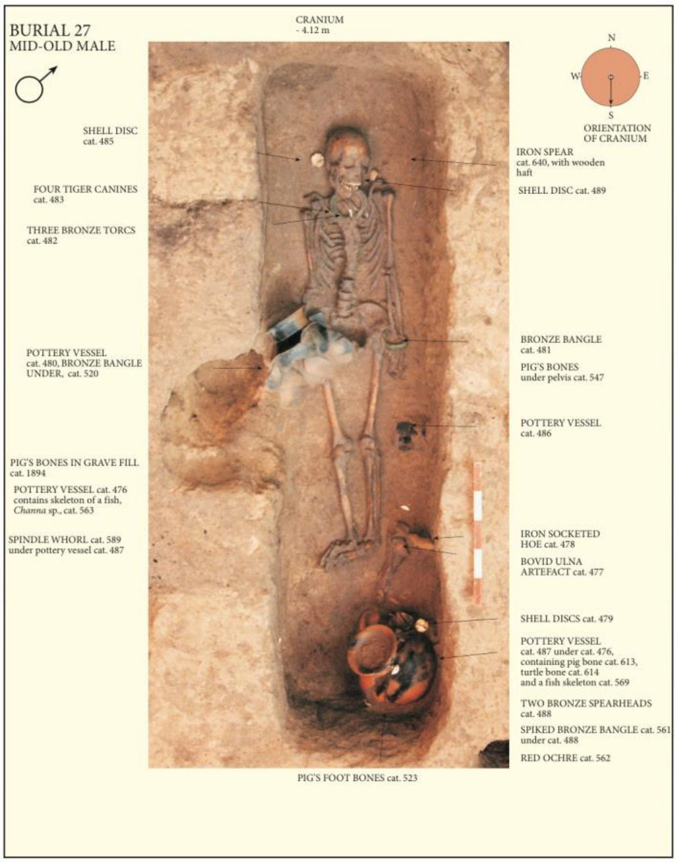

Figure 147: Location of burial goods and skeletal remains of Burial NUL 27 (take from Higham and Thosarat, 2007a).

9.2 Ban Non Wat

9.2.1 Productive and respected

Burial BNW155 has been ranked as the unhealthiest person in the Ban Non Wat sample. A mid aged male from the Mid Bronze Age, he suffered from slight DJD, which would not have affected daily life, but had suffered a spiral fracture to the clavicle, had extensive osteoblastic lesions (Table A 24 [p. 425]) on all the lower limb bones and a few metatarsals, evidence of muscle attachment damage on the arms and he also had periodontal cavities. The cause of the lesions on the lower limb bones is unknown. It is possible that he developed an infection in adulthood, possibly bacterial, but had recovered.

It appears that this person had an active life where heavy load stressors were placed on the body. This male would have most likely contributed to the community. In his grave, mourners placed a marble and a clay bangle, a bovid tibia, five pots, some unidentifiable bronze fragments and red ochre (Figure 148). The number of artefacts in this burial was average for the Mid Bronze Age and he had more pots than most of the sample in the period, but ornaments are poorly represented. He was also one of the few in the Mid Bronze Age who were buried with industrial goods, in this case a clay mould. Does this suggest that he made the clay mould or was a metal worker who used clay moulds to produce metal goods? The lesions found on the muscle attachments on his arms can be considered suggestive that he may have been a metal worker. If this interpretation is correct, then metal workers may have been buried with average to above average numbers of burial goods. This suggests that the burial ritual that occurred with this individual is indicative of an individual's practical worth to the community. He contributed to the community and mourners placed pottery goods and red ochre into his grave to mark their respect for him. He may have suffered a major level of infection in his legs but this episode did not define him.

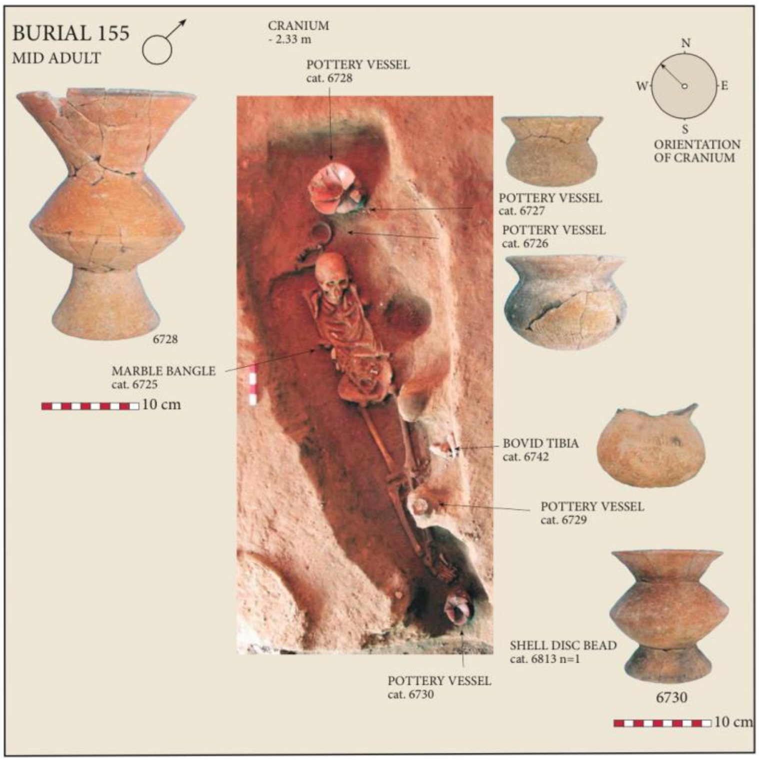

Figure 148: Location of burial goods and skeletal remains of BNW155 (taken from Higham and Kijngam, 2012).

At the Bronze Age site of Non Pai Wai, central Thailand, a metal worker was identified (NPW B5) based on the presence of ceramic bivalve mould fragments used to cast large socketed axes (Pigott et al., 2007). A male, his grave also contained an ochre grinding palette and hand stone, two pottery vessels and an ear ornament (Higham, 2002). Examined by Agelarakis (1996), the age of the individual was assessed at being over 35. The skeleton exhibited skeletal and dental pathologies, as well as traumatic injury to the dentition and post-cranial skeleton. His maxillary labial teeth also showed modifications that appear to be the result of habitual use or occupational damage. NPW B5 may have used his teeth to make rope (Agelarakis, 1996). He also suffered from osteoarthritis and spondyloarthropathies. NPW B5 dates from the Early Bronze Age and BNW155 lived during the Mid Bronze Age. Although Agelarakis did not specify the pathological skeletal insults found on NPW B5, these individuals appear to have suffered a similar health and life history. Both died during the peak of their ability to contribute to society, as mid adults. The similarities between these two individuals appear to confirm the suggestion that they were metal workers and that the moulds belonged to them. As an occupation, their lives appeared physically stressful and involved the risk of bodily harm. Health and burial goods, used in combination, assisted in identifying part of their life histories. It is difficult to associate ownership of burial goods to the deceased, but in this example health has played a major part in helping define ownership.

9.2.2 Family plots in the Late Bronze Age?

The three females that are buried oriented east contain two of the unhealthiest people in the sample (Figure 149). The third female is older yet healthier. Are they related, outcasts or part of a subgroup, such as potters? Is there a reason why they are buried oriented east as opposed to the north-south norm? Burial BNW218 is a mid-aged female who died in the Late Bronze Age. She was buried oriented east with three ornaments; large shell disc beads found at her ankles and on her chest (Figure 150). Two pots were placed with her as well as a conical roller and red ochre. Making an assumption regarding the purpose of the conical roller, its presence suggests that she or her family took part in pottery production. Whilst she had less than the average number of artefacts buried with her, she had more ornaments than most in the Late Bronze Age. Being buried east, she shares this with two other females in the Late Bronze Age sample, perhaps a sub-group. Although she was of average height, she suffered growth disturbances in childhood as she had severe EH and had periostitis on her femora, indicating an infection. Despite stressors in her childhood, she survived. It is possible that there were nutritional issues during that period, but that support networks were in place at some level to enable her recovery. This may have been additional nutrition support if this was the issue or medicinal support if disease was the cause. She appears to have some relationship to pottery manufacturing, but did not survive into old age. The periostitis on her femora suggests that she was ill as an adult, possibly weakening her so that she did not survive any further acute illness that would not have left any traces on the skeleton. This female indicates that the Late Bronze Age society of Ban Non Wat had the social capabilities to look after its sick, who were then able to contribute to society, if we can assume that she worked in the pottery production industry. Stressors in childhood and adulthood do not appear to have stopped her from working. The minor DJD found in a wrist bone may also indicate that she was a potter.

Burial BMW215 is also a mid-aged female and although she suffered severe childhood growth disturbance she is of above average height. Whatever the childhood stressor was, it did not unduly impact bone growth. She has some minor DJD and dental disease and some minor pathological lesions, seen in tibial periostitis, stressors evident at the bicep brachii muscle insertion point, as well as a small cranial lesion, which may be an indication of trauma. She was buried with 23 artefacts, which is well above the mean for the period and of these one was a shell ring and 14 were pots (Figure 151). There were also bronze arrowheads, a pigs foot, a clay axe mould, spindle whorl, clay rollers and anvil as well as a clay pellet. This burial would be one of the richest and most variable in range of grave goods in the Late Bronze Age. All burial goods types are represented and she was the lone individual in the Late Bronze Age sub-sample that had bronze bladed goods. It is difficult to assign a life role to this woman. Was she a hunter or warrior (arrowheads) or a metal worker (arrowheads and axe mould), or a potter (anvil and rollers), or a textile maker (spindle whorl). Or was she a wife or daughter of a hunter or metal worker? These goods do not appear to be a true representation of the individual, but of a sub-group, which is possibly her family and the loss that they felt at her death.

The last female in this sub-group is an older female (BNW227), who had a relatively healthy life. She was of above average height and had only suffered some minor DJD and dental problems. She was buried with five pots, spindle whorls and bivalve shells (Figure 152). The presence of the spindle whorl suggests she was a textile worker. An older woman who would have had many years to contribute to the workings of the community. But the death of an older woman, past her child bearing years, and losing the ability to work, may not be considered as significant as the death of a younger woman. The lack of burial goods does suggest that burial ritual at this point in time was focused on the mourning of the loss of a person who is contributing and can contribute further to the community.

Could the three women be related? Possibly. Two of the females are of above average height. The last suffered significant EH and is of average height, but if she was genetically predisposed to above average height, the fact that she is of average height may be an indicator of the poor health she suffered as a child.

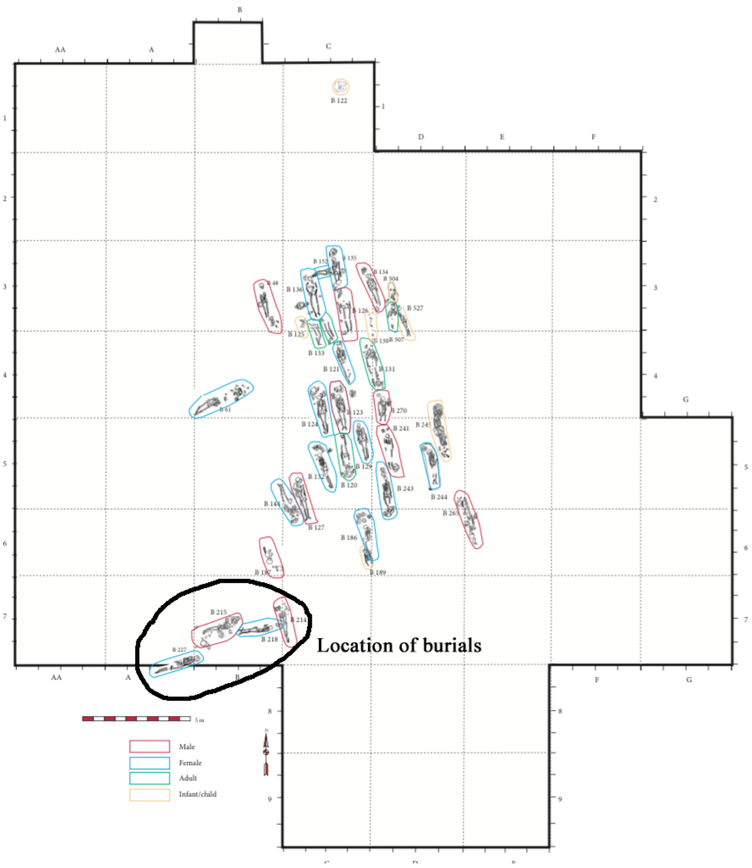

Figure 149: Location of Burials BNW 215, BNW218 and BNW227 is circled (adapted from Higham and Kijngam, 2012).

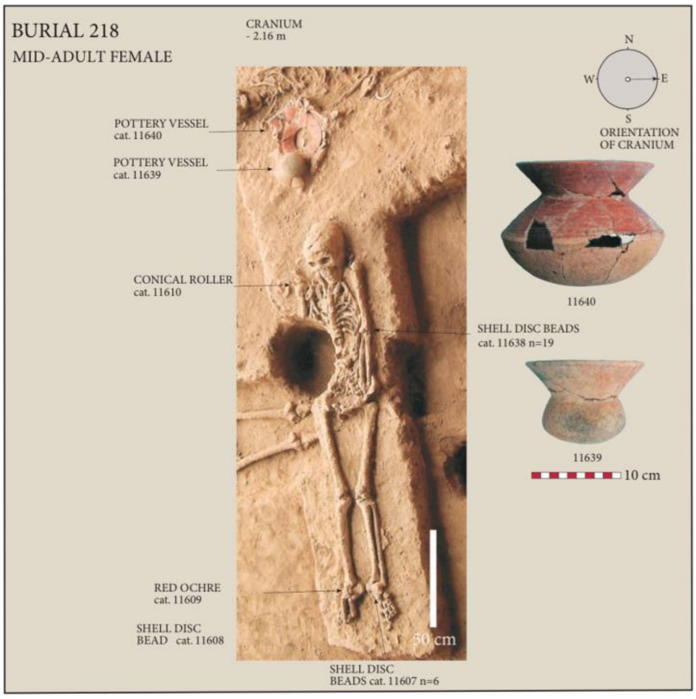

Figure 150: Location of burial goods and skeletal remains of BNW218 (taken from Higham and Kijngam, 2012) .

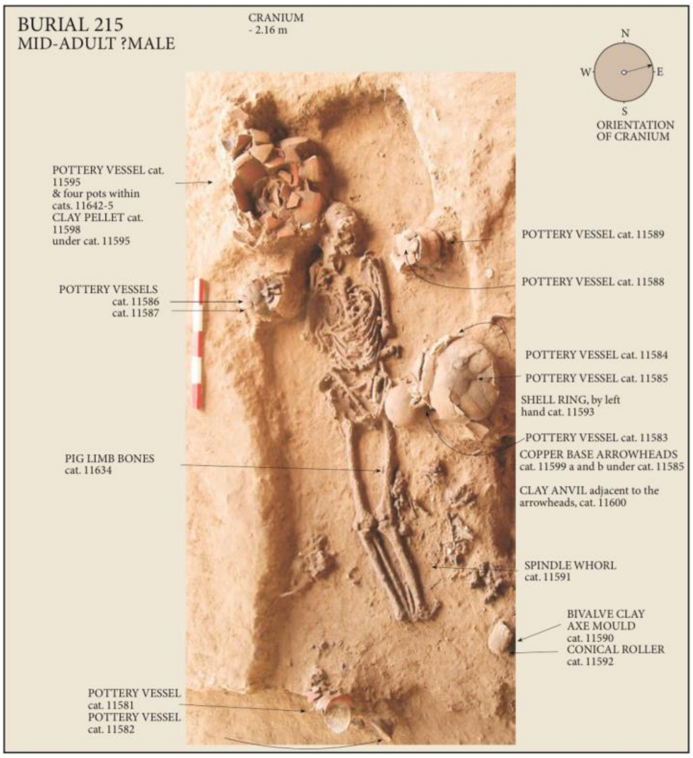

Figure 151: Location of burial goods and skeletal remains of BNW215 (taken from Higham and Kijngam, 2012).

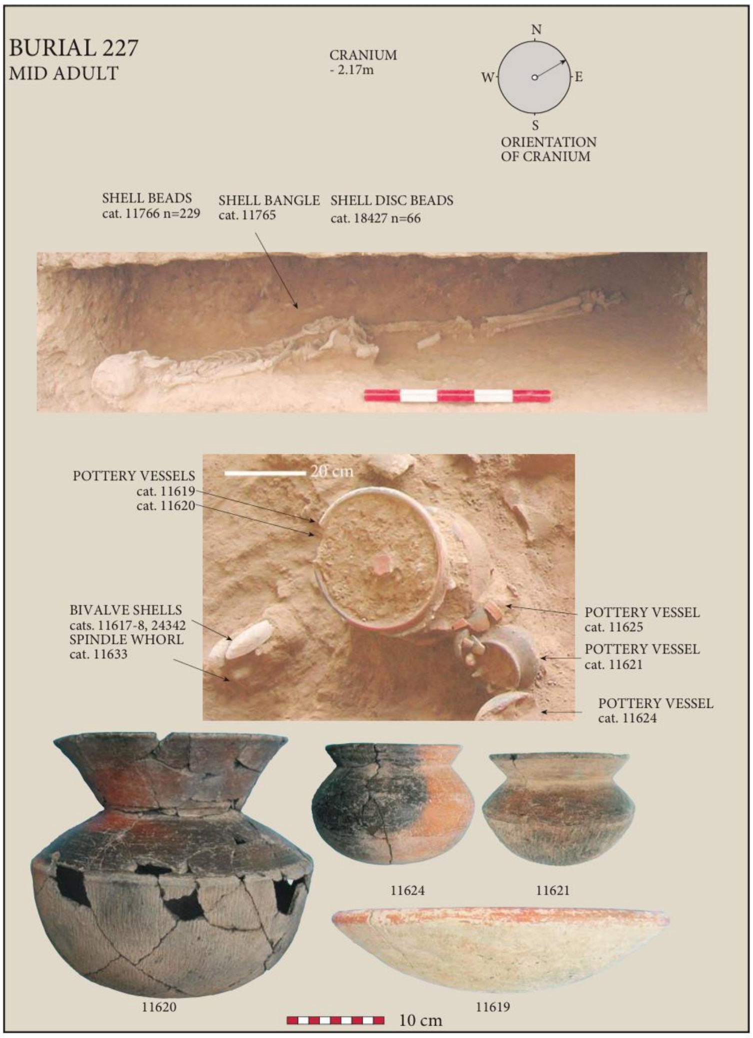

Figure 152: Location of burial goods and skeletal remains of BNW227 (taken from Higham and Kijngam, 2012).

10 DISCUSSION

This study was designed for two reasons. Principally, a methodology to quantify the overall health of an individual based on skeletal remains was developed, which could be of benefit to Southeast Asian studies of human remains in archaeological contexts. In addition, a method that could be used to further interdisciplinary studies in the field of bioarchaeology was considered an important outcome. To determine its usefulness it is used to investigate the transition period from the Late Bronze Age to Early Iron Age at two sites, Ban Non Wat and Noen U-Loke, in northeast Thailand. The purpose of this thesis is not to produce an all-encompassing interpretation of health and society in Ban Non Wat and Noen U-Loke. Rather, it is to provide alternative methods for interpretation and provide examples of how they can be achieved.

10.1 The methodology – a Southeast Asian Health Index

This study has demonstrated that developing a health index based on attributes that are related to information can be directly sourced from skeletal remains. It is a vital step towards producing a holistic study of Southeast Asian prehistoric populations. The methodology described in this thesis uses attributes that strictly relate to skeletal elements and do not include any complex calculations or extrapolative data, such as life tables derived from modern populations. The SEAHI provides an easily reproducible, comparable ranking system that can be used in prehistoric Southeast Asia. The simplicity of the methodology is its most appealing aspect, especially as any researcher can apply it to any prehistoric population. The Southeast Asian Health Index does not determine number of Quality Adjusted Life Years, as the WHHI does, but it does provide scores that can be used for a relational comparison between individuals, populations and sub-groups. In addition, as its use on poorly preserved skeletal material from Noen U-Loke demonstrates, its application is not restricted to only sites that are exceptionally well preserved.

This scoring system is much simpler, but also more encompassing, than that of the WHHI. The SEAHI methodology provides a useful process for determining the overall health of an individual at death: the SEAHI score; and it can be broken down to its components, or attributes, to look at specific health relationships. For example, a researcher only interested in dental health can examine the dental scores at a number of levels and ultimately can use the data to further interpret population health. Trends over time, such as the improvement of male dental health, can be easily identified. The SEAHI is useful in not only determining the health of an individual within a population or sub-group, but also assists in understanding how the individual interacted within their society. Another strength of the methodology is that it allows for new data to be added and the SEAHI to be recalculated. As new attribute data from newly excavated sites is collected, a regional health history can be formed. This can provide a valuable insight into regions and also assist in furthering multidisciplinary studies.

10.1.1 Testing of the SEAHI – what questions can be asked?

The performance of the SEAHI was tested against two sites. One of which had no interpretive information regarding health and society completed at the time of the SEAHI analysis (Ban Non Wat) and another that had been fully published and interpreted (Noen U-Loke). To test the SEAHI, a number of questions were asked using the Ban Non Wat and Noen U-Loke sample data.

10.1.1.1 Did the health of the people of Ban Non Wat and Noen U-Loke improve from the Late Bronze Age to Iron Age?

The SEAHI has the ability to relatively compare different populations from different phases. As a result of this we are able to determine if population health improved from the Bronze Age to the Iron Age. At both Ban Non Wat and Noen U-Loke an improvement in health over time can be identified in the SEAHI scores, but significant improvement cannot be directly associated from the transition from the Late Bronze Age into the Early Iron Age. Significant health improvement, however, can be seen, as there is a correlation between SEAHI scores and phase. Based on the results of this small sample, there is a significant change in health from the Early Iron Age to the Mid Iron Age. The Mid Iron Age samples are significantly healthier than those from earlier phases. The improvement in health is, as expected, complex. In general, a statistically significant improvement in health was seen in the male population. This improvement in health is also seen in the female population, where there is a gradual increase in positive health status through time. Far fewer pathological conditions are seen in the Mid Iron Age than in previous phases. The use of the SEAHI can assist in the identification of changes in society as health impacts society and vice versa. The results suggest that a positive change in health could be the result of community health access and/or the lessening of exposure to disease vectors through craft specialization. For example, as tasks become more specialized, such as pottery production, those craftspeople would no longer be required to plant or harvest rice and therefore would have less opportunity to acquire diseases resulting from contact with vectors found in rice paddies.

There are high levels of childhood growth disruptions in the Late Bronze Age, suggesting a period of stressors, such as nutritional stress, but by the Early Iron Age, Ban Non Wat no longer has high levels of growth disruptions. There are relatively high levels of pathologies in the Late Bronze Age, which perhaps suggest that there were outbreaks of disease, high pathogen loads and infection at this period. By the Early Iron Age, the stressors diminished at Ban Non Wat. The newly established Noen U-Loke had high levels of growth disruptions in the Early Iron Age. This is likely to be due to issues with establishing a new community. For example, food and supply networks need to be reorganised and established, and development of agricultural lands started. Delays to agricultural production may affect availability of food and flow on to impact upon population health. By the Mid Iron Age, the SEAHI scores show that population health issues have decreased. As Noen U-Loke is now a well-established village the stressors evident in the Early Iron Age are no longer occurring. This suggests a society with well-formed networks and practices. The SEAHI result used in conjunction with contextual data can provide further interpretations regarding the Mid Iron Age of Noen U-Loke. The lack of industrial goods in Mid Iron Age graves suggests that everyday items were not placed in graves, furthering the possibility that Noen U-Loke had become a specialized village and therefore lessening the variety of potential stressors amongst individuals.

Based on the samples used in this study, there are indications of transitional changes between the Bronze and Iron Age at Ban Non Wat and Noen U-Loke, but that these changes are not universal and are complex. This complexity is related to the potential stressors found in an established village as opposed to that of a village during development. Noen U-Loke, which appears to have a relatively unhealthy population in its establishment phase in the Early Iron Age, achieved a healthy population in a few hundred years.

10.1.1.2 Can health differentiation be seen between archaeological sites in the same region?

As a relational methodology, a measured evaluation of two sites is easily accomplished when they are contemporaneously occupied. The Early Iron Age is the only period when Ban Non Wat and Noen U-Loke are coexistent and are directly comparable. It would be difficult to compare the two sites if not for the SEAHI. Not only does it provide a fundamental comparison between the two sites but can also explore what aspect those differences relate to, such as growth disturbance or diet. Overall, the SEAHI scores show little difference between Ban Non Wat and Noen U-Loke. This suggests that, overall, the health between the two sites shows a similar level of stressors; both nutritional and environmental and both locations coped with these stressors in a similar way.

Examination of the SEAHI attributes provides additional information not immediately apparent in the raw data. Separating the different attributes from the SEAHI, we find that the dental health of the two villages is similar, as is trauma. Statistically there are differences in levels of enamel hypoplasia. Noen U-Loke suffered substantially higher levels of growth disruptions during childhood, however, long bone length scores are comparably similar. This may suggest that growth disruptions exhibited as EH versus those that affect long bones have dissimilar aetiologies or that catch up growth was possible in Noen U-Loke following the insults that caused the EH. Perhaps aligned with this outcome is the pathological score difference between Ban Non Wat and Noen U-Loke. Noen U-Loke is significantly poorer in pathological health than Ban Non Wat. This statistical difference in pathology scores is not linked to sex, it is an overall population based difference. This suggests that Noen U-Loke inhabitants had increased contact with pathogens. This may be linked to the childhood growth disruptions manifested in the EH.

Other statistically significant differences between Ban Non Wat and Noen U-Loke can be seen in the their joint disease scores. In the Early Iron Age, Ban Non Wat had higher levels of joint disease amongst the population. This suggests that a wider spectrum of the population were performing tasks that may have been mechanically load bearing. At Noen U-Loke the majority of the sample had no DJD.

The differences between the two sites in the Early Iron Age are evidence that the complexity of context is relevant. Two contemporaneous villages, within a short distance of each other, with dissimilar health demonstrate that local agricultural and social development as well as situation of place can influence the health of its inhabitants.

10.2 The Context - The Burial Ritual

The approach to burial context and “society” was not to impart any value or societal interpretation onto any goods. A typology of burial good types was devised: ‘ornament’, ‘pottery’, ‘animal bone’, ‘blade’, ‘industry’ and ‘other’. This typological method was undertaken to provide objectivity. In addition, other contextual information was gathered and placed within categories, without prejudice. These included orientation of the body, number of artefacts, number of ornaments, presence of wild animal burial goods and goods that appear to be unique within the sample. Any information that had been collected from both Ban Non Wat and Noen U-Loke was included. This impartial typological and categorical methodology has the potential to impart contextual information that could be useful in interpreting not only the burial ritual but also prehistoric society, including population health.

The patterns discerned following analysis of burial contextual information is highly relevant. Despite being neighbouring sites within walking distance, the burial ritual in the Early Iron Age appears to differ between the two sites. The most obvious example is the percentage of individuals with ornaments at Ban Non Wat drops dramatically from the Late Bronze Age to the Early Iron Age. The placement of ornaments was common, but appears strikingly less so in the Early Iron Age. On the other hand at Noen U-Loke, the Early Iron Age period sees a large percentage of the sample with ornaments. The question to ask is: Why are ornaments less important as a burial ritual item at Ban Non Wat in the Early Iron Age?

At Ban Non Wat, the importance of ornaments reduces in time, but appears to be an important and common burial item in the contemporaneous site of Noen U-Loke. The beliefs and ideas associated with ritual ornaments may be changing at Ban Non Wat, or simply ornaments are no longer considered to be a significant method of delineation of individual or group status in the burial ritual. It is not sufficient to state simply that ornaments were no longer used based on the latter reasoning, due to the intangible value of these ornaments, which we, as industrialized urban people with distinctly different social systems, cannot fully understand. Intangible values of ornaments may relate to religious symbology, rather than for a fundamentally decorative purpose. How these body ornaments relate to the values of the inhabitants of Bronze and Iron Age northeast Thailand is unknown. All we can discern is that ornaments were important psychologically to the inhabitants since they were placed in the graves of the dead. Even if these ornaments had something approaching our modern concept of financial importance and may have been items that would have been desired by the living, their use as a burial offering was considered more essential. Why one village altered its perceptions of ornaments compared to a neighbouring, contemporaneous village is a conundrum. It may suggest that the influence of society was localized and regional influences were limited.

Another difference between the Bronze and the Iron Age can be seen in the presence of animal bone in burials. In general, the percentage of individuals with animal bone increases markedly from the Late Bronze Age to the Early Iron Age. Animal bone appears to be an important part of the burial ritual in the Early Iron Age, but within a few hundred years it ceases to be important as no animal offerings are found in the Mid Iron Age sample. The most common animal offering in the Bronze and Iron Age of Ban Non Wat are suids. Less common are bovid and cervid bones as well as canids. The Iron Age also sees bovids and canids, but additionally aves, probably chicken, and fish offerings.

Pork may have been a major source of protein for the inhabitants of Ban Non Wat and Noen U-Loke. Pigs figure heavily in burial ritual offerings in both sites. Kim (1994) suggests that pigs were a prestige item in Neolithic China. Could the presence of pigs trotters in graves also suggest a prestige grave? There is a positive correlation between the presence of pigs bone and the number of artefacts in the grave (Table A 34 [p. 473]). This may also suggest that pigs are prestigious goods in the Bronze and Iron Age of Ban Non Wat. There is no correlation at Noen U-Loke.

The use of animal bone in burials appears to be centred on the meaning, symbolic, religious or otherwise, of the animal itself. Whilst we cannot hope to be able to determine the meaning of the animal and why it or a portion of the animal was placed in the grave, we can try to understand the common patterns. There are a number of potential explanations to the placement of animal offerings in human graves. These include (from Pollex, 1999):

- As a social status indicator,
- Part of a religious offering, for example showing respect for the gods or spirits,
- An emotional offering of beloved, respected or feared animals; and
- Totemistic offerings of group affiliation.

Some items from Noen U-Loke, such as wild animal tusks, have been interpreted as being amulets of feared or respected animals (Talbot, 2007). These may also be totemistic offerings or, as suggested in this thesis, a medicinal offering for strength in the next life. The presence of domesticated or farmed animals is far more difficult to interpret.

There is a gradual decline in the percentage of individuals with pottery through time. The analysis shows that all individuals in the Mid Bronze Age sample were buried with pottery. By the Early Iron Age, only just over half of the sample have pottery. This may imply that by the Early Iron Age pottery was not a common burial good in that its use was only for certain individuals. This may be an indicator of a progressively stratifying society or simply the lessening of importance of pottery as a mortuary item. As pottery production becomes more common, with craft specialist 'pottery' villages becoming more prominent, pottery may have become a less desirable item for demonstrating social status. Alternatively, it may have become more difficult to obtain economically.

Industrial goods appear to be indicators of social status in the Mid Bronze Age. Those with industrial goods during this period appear to have numerous other burial goods, such as ornaments, pottery and other goods. The appearance of these burials superficially suggest high status. This status would reflect the individuals importance to those within the community. The Late Bronze Age includes the most individuals by percentage with industrial goods. This shows that craftspeople were also highly regarded and their roles in life were part of the burial ritual process. The Iron Age reveals a marked decrease in industrial goods. This change can indicate that social status was changing at the time and that crafts were no longer an integral part of whether or not prestige or respect was placed on a person. As craft specialization takes place, groups form and respect is found within those groups.

'Other' types of goods are prominent in the Bronze Age. These have been interpreted to be additional markers within the burial ritual, which may be of a religious or symbolic significance – such as red ochre offerings. Red ochre has been an important burial offering over millennia in numerous cultures (Boric and Stefanovic, 2004, Straus et al., 2011, Pettitt, 2011). Although generally associated with art, it has been suggested that red ochre is symbolic of blood (Wreschner, 1980). Wreschner (1980) recalls a Maori legend of a woman who had died and in the afterlife found a bowl of red ochre, which she ate and was brought back to life as a result. Other cultures have used red ochre, as well as other colours, to paint their bodies for ceremonial purposes, such as tribal aboriginal people of Australia. The significance of red ochre appears to be diminished as burial rituals diverge from being symbolic, tribal events to those of status (individual or group) elaboration.

Looking at the Iron Age, mainly in Noen U-Loke, these 'other' offerings decline within the population until they seem to be irrelevant in the Mid Iron Age, where ornamentation becomes the main form of burial good and a major identifier of group status.

By examining burial goods and contextual information, we can discern some features of society in each location and time phase. Based on the sample, Ban Non Wat appears to be a familial community, where those that have provided the most contribution to the community, the elderly and the craftspeople, are considered the most important people. This is reflected in the burial ritual. The transition to the Iron Age sees changes, in that perceived identity becomes more important, as evidenced in the cluster burials of Noen U-Loke. The role that the person played in life becomes less important. Perception of group identity becomes much more important. This, perhaps, is the beginning of stratification in the late Early Iron Age.

10.3 Holistic Approach - Health and Burial Treatments

Using the SEAHI in combination with contextual burial data also assists in our understanding of prehistoric Southeast Asia. Archaeologists and anthropologists have been pondering the social status of individuals in archaeological sites for a long time. How can we be sure that the descriptions of societies identified in archaeological sites are accurate? The simple answer is that we cannot. Studies of goods found within graves cannot accurately portray the contemporaneous living environment. Can we say for certain that burial goods were easily acquired for unexpected deaths? Could 'rich' burials signify an expected death and a 'poor' burial one where the death was unexpected? Interpretations of archaeological sites have at times mirrored the archaeologists own beliefs, political climate and modern society's concepts. This is seen by the importance given to wealth assessments in numerous cemetery sites. In modern societies, the issue of wealth is very important, and Western archaeologists believe that, as a result, that this is a very important topic to study in ancient sites as a result.

The burial goods, placement of a burial within a cemetery, orientation, burial receptacle (for example, a coffin) are all contextual data (Harris, 2010). By examining these data along with health data, we may be able to identify patterns and relationships that we have not encountered before or have not been able to identify previously. This example is clearly seen in the young male (NUL26) at Noen U-Loke who was buried with the pig tusk and red ochre. Based on the burials goods it would have been easy to regard him as a hunter, but in combination with his SEAHI assessment, this appears an unlikely occupation as this young man was unhealthy over his short lifetime. The items that connect his social identity to that of a 'hunter' have to be reassessed in light of this.

The archaeological excavation of cemetery sites generates a massive amount of data. These data need to be comprehended. As there may be numerous specialists generating these data, there needs to be a way of incorporating the data in a coherent and inter-disciplinary manner. In most cases, as seen in the Noen U-Loke report (Higham et al., 2007), there is little interaction between health interpretations of individuals and the analysis of burial goods. There appears to be a disconnection between archaeological and bioanthropological assessments, when they should be interconnected. The SEAHI and burial goods analysis in this thesis assists partly to address this issue and show that these two disciplines do not have to be treated separately.

10.3.1 Is there a correlation between burial treatment and health?

The main interdisciplinary methodology in this thesis utilised correlation analysis of burial treatment attributes and SEAHI scores. There are a number of relationships between health and burial treatment. The elucidation of those relationships is now the challenge. For example, those that were buried with blades are healthier than those who were not. Are these blades symbolic items or indicators of tasks that the individual undertook? Are they symbolic of the strong and healthy? Or perhaps are they the "wealthy" with few stressors in life?

Interpretations linked to medical "treatment" can be made. There may be evidence of medical aides within the burial ritual, specifically ornaments. Burials at Ban Non Wat without ornaments are healthier. It appears that many individuals who were relatively unhealthy were buried with an ornament, possibly an amulet. This is especially evident in the female sample. Were ornaments at Ban Non Wat used as medicinal amulets that would protect the wearer in the after life? Or were they to protect the living? If so, in either circumstance, why were they not used in all unhealthy cases? The inhabitants of Noen U-Loke do not appear to have used ornaments in this fashion. This could suggest a culturally different group or a change in psychological belief. Males with animal bone at Noen U-Loke are significantly unhealthy compared to those without. Could the animal bone also be a medical aide?

Correlations were also found with other types of contextual information. Those buried oriented east are also unhealthier, but many have animal bone. Are the unhealthy buried with animal bone or are they buried oriented east? Or both? Those oriented east may be a sub-group of the community, who have suffered an unhealthy life and who are interred oriented east due to cultural reasons or for 'medical' reasons.

The number of burial good types an individual has also correlated with health scores. Having more burial good types does not necessarily mean that a person is of 'high' status and healthier as they do not undertake strenuous tasks. In the Mid Bronze Age, it appears that the more variability in burial goods an individual has, the less healthy the individual. This 'richness' in goods may not equate to a 'wealthy' person, but perhaps a functionally important person who has contributed physically to the community through their work. These people were important to the operation of the village and their burial goods are reflective of their contribution. Conversely, these individuals have not have been healthy over their lifetime, and may not have been able to contribute greatly to the community. The variety of goods may, in fact, reflect the belief in the afterlife and what that person required in order to be stronger. Symbolically these people were made healthier after death. The person who had the lowest score in the Mid Bronze Age had the highest number of burial good types (five) and closer examination of the health data shows that he had severe pathological lesions. Therefore, the latter notion of burial goods as ‘medical’ aides for the dead may be viable. The results of the correlation analysis confirms that the combination of SEAHI and contextual burial treatment data can provide valuable information and interpretations that have not been considered previously.

10.3.2 Is there a correlation between health and burial treatment that reflects social identity?

Sub-chapter 9 contains a selection of individuals whose social identity could be recognised, in part, using health and burial treatment data. The health attributes that are collected from skeletal remains found in archaeological contexts contain information that goes beyond the naming of a medical condition. Understanding the condition provides insight into the daily life of an individual. How they obtained the condition, what activities they did, how a condition affected them and their interaction with the wider community can possibly be interpreted. The burial treatment, including burial goods and how the body was buried, can also provide information regarding that individual. Together, the two sources of information complement each other and further our understanding of an individual. Whilst the data collected from burials, health or burial treatment, could never fully untangle the complexities of an individual’s social identity, it provides further insight into that society as well as the individual. The aspects of social identity that can be unravelled using this combination of information is an important step and ultimately provides further tangible connections to the past.

10.3.3 Did society become more stratified from the Late Bronze Age to the Iron Age?

The final assessment of the burial treatment methodology used in this thesis is to determine if evidence of stratification can be identified. The impact of stratification can be seen in the control of goods, large scale community works, as seen in moat and canal construction, and increased craft specialization. Health indicators, such as the SEAHI, can also be utilised to assist in the interpretation of stratification at an individual level.

Can we see stratification in the individual burial treatments at Ban Non Wat and Noen U-Loke? How would have the people of Ban Non Wat and Noen U-Loke signified the death of an important person? There are a number of complications that make identifying ‘important’ people difficult. For example, goods that were solely for the use of burial ritual may not have always available at short notice. In the case of an unexpected death, grand burial offering gestures may not have been possible.

It is suggested that if a person of prestige did die, then a delay would take place where burial offerings were made or purchased. Would the climate of northeast Thailand allow a delay in burial? In Ban Non Wat there were burials where non-articulated skeletons were found, which may imply that they were not buried immediately after death. Their bones may have been temporarily stored or placed in a coffin for a period of time and when the remains were finally buried the flesh had decomposed leaving only bones. The bones could have become disarticulated during this period if there was any movement of the coffin. In addition, once these individuals were permanently buried, they may have had little in the way of offerings, but the act of viewing the deceased or their temporary storage may have been a significant ritual. At Noen U-Loke, the Early Iron Age appears to be a period of social unrest where emphasis on social groups was required in the establishment of power. The burial ritual is a social event and it may have signified the end of a branch in a social network. Participants in the funeral were in effect lamenting that end and beginning the reorganisation of that network. It is an opportunity to renegotiate, begin or end social alliances. Perceived status becomes more important later, as suggested by the cluster burials of Noen U-Loke. This period, in the late Early Iron Age, may be evidence of the start of a stratified society.

We can make some assumptions regarding the occupation or status of an individual based on what goods with which they were buried, but not on all occasions. A female burial (BNW215) containing industrial goods relating to metal working, pottery production and weaving, as well as hunter/warrior goods, is difficult to interpret. Does the presence of all these items identify her as wealthy? Do the items belong to her and did she use them? Does this show that craft specialisation had not taken place as yet and pottery production, weaving and metal working was still a domestic based activity? Her life was difficult, with childhood growth disturbances and a number of medical events affected her, evident in the lesions found on her skeleton. Her grave was comparatively 'rich' for the Late Bronze Age. The items may not represent her individual social identity but the identity of her family or social sub-group. The percentage of individuals with industrial goods peaks in the Late Bronze Age. This suggests that these goods have some significance to the community. The increasing lack of industrial goods in the Iron Age shows that craft specialisation may have been taking place during that time. Burial goods are likely to be a mix of the personal belongings of the dead person as well as offerings from those participating in the burial ritual. Definitively determining if the objects belonged to the deceased during life is not possible. It is also not always possible to determine why mourners placed specific offerings in the grave.

Stratification cannot be definitively identified in the burial treatments found in the samples from Ban Non Wat and Noen U-Loke. The complexities within each village needs to be better understood if we are to reconstruct individual social networks and how they changed overtime. Ban Non Wat was a village with a long history of occupation whilst the data from Noen U-Loke shows that it was at the beginning of its life as a village. This is evident in the difference in burial goods between the sites during the Early Iron Age. The high deposition of ornaments in the graves of Noen U-Loke individuals at this time could be indicative of a campaign of status establishment within the newly formed community.

10.4 Summary - The Transition from the Bronze Age to the Iron Age

One of the objectives of the development of the SEAHI and the use of the typological burial good analysis was to identify any modifications in burial ritual behaviour and health status from the Bronze Age to the Iron Age in northeast Thailand. Many aspects of health and burial ritual were examined based on a sample from two sites: Ban Non Wat, which was occupied from the Neolithic to the Early Iron Age; and Noen U-Loke, which had evidence of occupation in the Early and Mid Iron Age. The analysis of the two sites has identified issues in the investigation of the transition of the Bronze to the Iron Age. There are complexities within each site that have an effect on the analysis of health and burial ritual. Table 89 lists some of the main identifiable features or changes between the different phases.

A number of correlations were identified within this study. The main challenges are that correlations need to be interpreted in the context of other correlations. For example, if the Early Iron Age of Noen U-Loke is the unhealthiest place and time, where animal bone is a common burial good, is the animal bone really an indicator of poor health or simply just a common burial ritual item? Is animal bone unjustly linked to poor health? Complexity is important in the unravelling of stories regarding prehistoric populations. Interpretations can be difficult, but more importantly there is still an ongoing progression in relation to these interdisciplinary studies.

Table 89: Brief summary of features or transitional changes through time of burial goods and health at Ban Non Wat and Noen U-Loke.

MID BRONZE AGE	LATE BRONZE AGE	EARLY IRON AGE	MID IRON AGE
Burial Treatments			
		Animal bone at highest levels	No animal bone
All individuals with pottery		Just over ½ with pottery	
		Most of NUL have ornaments	Almost all have ornaments
	Industrial goods most prominent	Large reduction of industrial goods	
	'Other' goods common in Bronze Age		'Other' goods are not common.
Health Status and Burial Treatments Relationships			
More burial good types = unhealthy			
Animal and industrial goods in combination = unhealthy		Pottery at NUL = unhealthy	
		East oriented = unhealthy	
Blades = healthier		Animal = unhealthy	
Health Status			
Overall poorest health			Overall best health
	Growth disruption in childhood is high	Growth disruption in NUL, not BNW	
	Taller than average height	Average heights	
	Pathological lesions high		
Lowest trauma score			
All individuals with DJD	Most with DJD		Very little DJD
Poorest dental health		Decline in dental health	Best dental health
Summary			
Ascribed familial status important. Health is poor.	Health disruptions. Status of the individual related to contribution value to society - industrial task important.	Ornaments signify status establishment items. Poor health in societies that are being established. Perceived identity is important.	NUL has become established and health improves and burial goods become standardised – mainly ornaments.

10.4.1 Hypotheses summary

The results of the five hypotheses tested in this study are summarised:

1. The health of the people of Ban Non Wat and Noen U-Loke improved from the Late Bronze Age to Iron Age.

   The health of Ban Non Wat and Noen U-Loke populations improved over time, but there are complexities in this result. The most significant improvement in health can be seen between the Early Iron Age and the Mid Iron Age. The Mid Iron Age appears to be a period of social change, when villages become more specialized and social stratification commences. In an increasingly ranked society, seen in the Mid Iron Age, the health status of the population increases positively. This improvement in health is seen in both sexes. Male health sharply improves in the Mid Iron Age, but the female population has gradual increases in positive health status through time.

   Noen U-Loke appears to be a new community that has emerged due to the intensification of agriculture. The health of this emergent community is poorer than the established neighbouring community. Once established, with the new technology assisting in the production of agricultural goods, such as iron tools, Noen U-Loke becomes healthier. Perhaps the new technology enabled parts of the population to be engaged in craft specialization, rather than agriculture. The removal of exposure to disease vectors would have had a positive impact on the population's health.

2. Health differentiation can be seen between archaeological sites in the same region.

   During the Early Iron Age, which is the only contemporaneous time period that data exists for both sites, there is a difference in population health. This demonstrates the complex intricacies of health and society. Whilst an overall trend for an improvement in health over time was evident, the differences between the sites in the Early Iron Age shows that local development location can influence the health of its inhabitants.

3. There is a correlation between burial treatment and health.

   There appears to be a correlation between health and burial treatment. Females buried with ornamental goods appear to be of poorer health than females that do not have these goods. In addition, males with animal bones grave goods also appear to be of poorer health over all. In the site of Noen U-Loke, those people buried oriented to the east are statistically unhealthier than those oriented in other directions. Whilst the complexities of health and burial treatment are wide ranging, it appears that an investigation at the individual level is also required to further define the correlation found here.

   The purpose of some burial goods may be related to the living health of the deceased. Whether or not the inhabitants believed in a life after death is contentious, but it appears some burial *treatments may be directly associated with providing the deceased with strength in the afterlife.*

4. Correlation between health and burial treatment reflects social identity.

   Investigation at the individual level, using a combination of burial treatment and health analysis showed that some aspects of a person's social identity could be distinguished. The combination of health over a lifetime and interpretations of burial goods opens a window into the social identity of a person that would not have been seen based on burial goods alone.

5. Society became more stratified from the Late Bronze Age to the Iron Age.

   There is no evidence of a stratified society per se, based on the current study. There are elements of the development of craft specialization, but no trends that show that society was becoming more stratified. What we are seeing is the continuation of one village with a long history of occupation (Ban Non Wat) and the beginning of another village (Noen U-Loke). Noen U-Loke exhibits some level of stratification, based on what appears to be exhibition of status and positions of prestige seen in the level of ornaments in individual burials and at a family or sub-group level seen in the clustering of burials.

10.4.2 Research directions and conclusions

The use of the SEAHI, provides a great step forward in setting the ground rules for bioarchaeology. This approach avoids the common errors made when using health attributes to support interpretations of social complexity and the 'wealth' status of individuals. It has a sound basis and can be used in many regions of the world, albeit in a modified format. The ideal way to deal with health and society would be to rank individuals based on health using many variables. In this way, the most comprehensive view of the population can be provided and a broad, regional view of Southeast Asian prehistory can be attained.

Whilst health determining status can follow a solid and useful methodology, social status identification methodologies of prehistoric sites are currently much more contentious. No single method or combination of methods can effectively identify the status or wealth of an individual. Furthermore, it is unlikely that this position will change. Whilst it appears that investigating status directly is not useful, investigations of the burial characteristics, including associated goods can still provide valuable information regarding society. New variables used to investigate burials can only identify new patterns, but nevertheless this is important. The patterns do not necessarily only have to identify 'status', for example, it may be possible to identify new migrants or paleo-enviromental change. This approach can still lead to useful intra-site and inter-site comparisons using multi-disciplinary methodology. To this end, the present study uses a form of typological analysis. The typology of burial can be related to 'society'; in the differential treatment of individuals. In this way health can be compared to society. Without doubt, this method of typological analysis can be further developed and refined.

This study provides a framework for future studies of Southeast Asia, if not globally. A broadscale study of health and society has yet to be attempted in Southeast Asia. This will enable the comparison of health between individuals as well as groups through time and space. Combining it with consideration of society can provide a more holistic view of the lifestyle of populations. Health interpretations, on their own, lack context. Placing health with burial goods types provides context and insight.

11 REFERENCES

AGELARAKIS, A. 1996. The Archaeology of Human Bones: Prehistoric Copper Producing Peoples in the Khao Wong Prachan Valley, Central Thailand. *Indo Pacific Prehistoric Association Bulletin,* 14**,** 133-139.

AL-SALIHI, A.R., AL-AZAWI, E.H., JAFFAR, A.A. & BAKR, F.A. 2002. Skeletal Age Determination of the Symphysis Pubis for Forensic Purposes: Analysis of an Iraqi Series. *Mankind Quarterly,* 42**,** 345-353.

ALBRECHT, G., HAIDLE, M.N., SIVLENG, C., HONG, H.L., SOPHADY, H., THAN, H., SOMEAPHYVATH, M., KADA, S., MOPHALM, S., CHANTHOURN, T. & LAYCHOUR, V. 2001. Circular Earthwork Krek 52/62: Recent Research on the Prehistory of Cambodia. *Asian Perspectives,* 39**,** 20-46.

ALEKSHIN, V.A. 1983. Burial Customs as an Archaeological Source. *Current Anthropology,* 24**,** 137-147.

ALESAN, A., MALGOSA, A. & SIMO, C. 1999. Looking into the Demography of an Iron Age Population in the Western Mediterranean. I. Mortality. *American Journal of Physical Anthropology,* 110**,** 285-301.

ALVES, R.R. & ALVES, H.N. 2011. The Faunal Drugstore: Animal-Based Remedies Used in Traditional Medicines in Latin America. *J Ethnobiol Ethnomed,* 7**,** 9.

ALVES, R.R.N., PINTO, L.C.L., BARBOZA, R.R.D., SOUTO, W.M.S., OLIVEIRA, R.E.M.C.C. & VIEIRA, W.L.S. 2013. A Global Overview of Carnivores Used in Traditional Medicines. *In:* ALVES, R.R.N. & ROSA, I.L. (eds.) *Animals in Traditional Folk Medicine.* Springer Berlin Heidelberg, 171-206.

ANDREWS, C. 1994. *Amulets of Ancient Egypt,* University of Texas Press.

ANDRUSHKO, V.A. 2007. *The Bioarchaeology of Inca Imperialism in the Heartland : An Analysis of Prehistoric Burials from the Cuzco Region of Peru.* Doctor of Philosophy, University of California.

ANGEL, J.L. 1966. Porotic Hyperstosis, Anemias, Malarias, and Marshes in the Prehistoric Eastern Mediterranean. *Science,* 153**,** 760-763.

APPOLLONIO, I., CARABELLESE, C., FRATTOLA, A. & TRABUCCHI, M. 1997. Influence of Dental Status on Dietary Intake and Survival in Community-Dwelling Elderly Subjects. *Age and Ageing,* 26**,** 445-456.

ARANDA-JIMÉNEZ, G., MONTÓN-SUBÍAS, S. & JIMÉNEZ-BROBEIL, S. 2009. Conflicting Evidence? Weapons and Skeletons in the Bronze Age of South-East Iberia. *Antiquity,* 83**,** 1038-1051.

ARGYLE, M. 1969. *Social Interaction,* London, Methuen.

ARMELAGOS, G.J. 2003. Bioarchaeology as Anthropology. *Archeological Papers of the American Anthropological Association,* 13**,** 27-40.

AUFDERHEIDE, A.C. & RODRIGUEZ-MARTIN, C. 1998. *The Cambridge Encyclopedia of Human Paleopathology,* Cambridge, Cambridge University Press.

AYKROYD, R.G., LUCY, D., POLLARD, A.M. & ROBERTS, C.A. 1999. Nasty, Brutish, but Not Necessarily Short: A Reconsideration of the Statistical Methods Used to Calculate Age at Death from Adult Human Skeletal and Dental Age Indicators. *American Antiquity,* 64**,** 55 - 70.

BACUS, E. 2006. Social Identities in Bronze Age Northeast Thailand: Intersections of Gender, Status and Ranking at Non Nok Tha. *In:* E.BACUS, I.G., V.PIGOTT (ed.) *Uncovering Southeast Asia's Past.* Singapore: NUS Press, 105-115.

BAKER, J.L. 2012. *Funeral Kit: Mortuary Practices in the Archaeological Record,* Walnut Creek, CA, USA, Left Coast Press.

BANNANURAG, R. 1991. Khok Phanom Di: Mortuary Data and Social Information. *Indo Pacific Prehistoric Association Bulletin,* 11**,** 204-209.

BARNARD, A. (ed.) 2004. *Hunter Gatherers in History, Archaeology and Anthropology,* Oxford: Berg.

BARRIBEAU, T. 2011. The Bronze Age Mortuary Vessels of Ban Non Wat. *Asian Perspectives: Journal of Archaeology for Asia & the Pacific,* 50**,** 91-106.

BASKIN, B., SOPHEARA, C., THYDA, P. & SOKHA, T. n.d. Progress Report: The Ceramics Conservation Lab, Phnom Penh.

BAYARD, D. 1984. A Tentative Regional Phase Chronology for Northeast Thailand. *In:* BAYARD, D. (ed.) *Southeast Asian Archaeology at the X.V. Pacific Science Congress 16.* Dunedin: Otago University, 161-168.

BAYARD, D.T. 1984. Rank and Wealth at Non Nok Tha: The Mortuary Evidence. *In:* BAYARD, D.T. (ed.) *Southeast Asian Archaeology at the X.V. Pacific Science Congress: Papers Presented in Symposium, Dunedin, New Zealand, 8-10 February 1983* University of Otago: Dept. of Anthropology 87-122

BELCASTRO, G., RASTELLI, E., MARIOTTI, V., CONSIGLIO, C., FACCHINI, F. & BONFIGLIOLI, B. 2007. Continuity or Discontinuity of the Life-Style in Central Italy During the Roman Imperial Age-Early Middle Ages Transition: Diet, Health, and Behavior. *American Journal of Physical Anthropology,* 132**,** 381-394.

BELCASTRO, M.G., MARIOTTI, V., FACCHINI, F. & DUTOUR, O. 2005. Leprosy in a Skeleton from the 7th Century Necropolis of Vicenne-Campochiaro (Molise, Italy). *International Journal of Osteoarchaeology,* 15**,** 431 - 448.

BELL, R.W. & SENG, V. 2004. Rainfed Lowland Rice-Growing Soils of Cambodia, Laos, and North-East Thailand. *In:* V.SENG, CRASWELL, E., FUKAI, S. & FISCHER, K. (eds.) *Water in Agriculture.* Canberra: Australian Centre for International Agricultural Research,

BELLO, S.M., THOMANN, A., SIGNOLI, M., DETOUR, O. & ANDREWS, P. 2006. Age and Sex Bias in the Reconstruction of Past Population Structures. *American Journal of Physical Anthropology,* 129**,** 24-38.

BELLWOOD, P. 2006. Asian Farming Diasporas? Agriculture, Languages, and Genes in China and Southeast Asia. *In:* STARK, M.T. (ed.) *Archaeology of Asia.* Oxford: Blackwell Publishing, 96 - 118.

BENDER, B. 1995. The Roots of Inequality. *In:* MILLER, D., ROWLANDS, M. & TILLEY, C. (eds.) *Domination and Resistance.* London: Routledge, 83-93.

BENTLEY, R.A., TAYLES, N., HIGHAM, C., MACPHERSON, C. & ATKINSON, T.C. 2007. Shifting Gender Relations at Khok Phanom Di, Thailand. *Current Anthropology,* 48**,** 301-314.

BINFORD, L. 1971. Mortuary Practices: Their Study and Their Potential. *In:* BROWN, J.A. (ed.) *Approaches to the Social Dimensions of Mortuary Practices.* Memoirs of the Society for American Archaeology, 6-29.

BISHOP, P., SANDERSON, D.C.W. & STARK, M.T. 2004. O.S.L. And Radiocarbon Dating of a Pre-Angkorian Canal in the Mekong Delta, Southern Cambodia. *Journal of Archaeological Science,* 31**,** 319-336.

BOGIN, B. 1988. *Patterns of Human Growth,* Cambridge, Cambridge University Press.

BONFIGLIOLI, B., BRASILI, P. & BELCASTRO, M.G. 2003. Dento-Alveolar Lesions and Nutritional Habits of a Roman Imperial Age Population (1st - 4th C. A.D.): Quadrella (Molise, Italy). *Homo,* 54**,** 36-56.

BONNICHSEN, R. 1973. Millie's Camp: An Experiment in Archaeology. *World Archaeology,* 4**,** 277-291.

BORIC, D. & STEFANOVIC, S. 2004. Birth and Death: Infant Burials from Vlasac and Lepenski Vir. *Antiquity,* 78**,** 526-546.

BOUQUET-APPE, J.P. & MASSET, C. 1982. Farewell to Paleodemography. *Journal of Human Evolution,* 11**,** 321 - 333.

BOYD, W.E. 2008. Social Change in Late Holocene Mainland S.E. Asia: A Response to Gradual Climate Change or a Critical Climatic Event? *Quaternary International,* 184**,** 11-23.

BOYD, W.E. & CHANG, N. 2010. Integrating Social and Environmental Change in Prehistory: A Discussion of the Role of Landscape as a Heuristic in Defining Prehistoric Possibilities in Ne Thailand. *In:* HABERLE, S., STEVENSON, J. & PREBBLE, M. (eds.) *Terra Australis: 21: Altered Ecologies - Fire, Climate and Human Influence on Terrestrial Landscapes.* Canberra, ACT: ANU E Press, 273-297.

BOYD, W.E. & HABBERFIELD-SHORT, J. 2007. Geoarchaeological Landscape Model of the Iron Age Settlements of the Upper Mun River Floodplain. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 1-27.

BOYLE, M.H. & TORRANCE, G.W. 1984. Developing Multiattribute Health Indexes. *Medical Care,* 22**,** 1045-1057.

BRANDT, K.D. 2008. Etiopathogenesis of Osteoarthritis. *Rheumatic Diseases Clinics of North America* 34**,** 531-559.

BRIGGS, L.P. 1951. The Ancient Khmer Empire. *Transactions of the American Philosophical Society,* 41**,** 1-295.

BROTHWELL, D.R. 1981. *Digging up Bones,* Third Edition, Oxford, Oxford University Press.

BROWN, J.A. 1971. The Dimesions of Status in the Burials at Spiro. *In:* BROWN, J.A. (ed.) *Approaches to the Social Dimensions of Mortuary Practices.* Society for American Archaeology, 92 - 112.

BROWN, R. 2000. Social Identity Theory: Past Achievements, Current Problems and Future Challenges. *European Journal of Social Psychology,* 30**,** 745-778.

BRÜCK, J. 2004. Material Metaphors: The Relational Construction of Identity in Early Bronze Age Burials in Ireland and Britain. *Journal of Social Archaeology,* 4**,** 307-333.

BUCKLEY, H. & DIAS, G. 2002. The Distribution of Skeletal Lesions in Treponemal Disease: Is the Lymphatic System Responsible? *International Journal of Osteoarchaeology,* 12**,** 178-188.

BUIKSTRA, J. & KONIGSBERG, L.K. 1985. Paleodemography: Critiques and Controversies. *American Anthropologist,* 87**,** 316 - 333.

BUIKSTRA, J.E. & UBELAKER, D. (eds.) 1994. *Standards for Data Collection from Human Skeletal Remains,* Fayetteville: Arkansas Archaeological Survey Press.

BUT, P. 1995. Conservation of Tigers and Bears for Sustainable Use in Chinese Medicine. *International symposium on traditional Chinese medicine and wildlife conservation.* Hong Kong: TRAFFIC, WWF and Government of Hong Kong

CANCI, A., NENCIONI, L., MINOZZI, S., CATALANO, P., CARAMELLA, D. & FORNACIARI, G. 2005. A Case of Healing Spinal Infection from Classical Rome. *International Journal of Osteoarchaeology,* 15**,** 77-83.

CANNON, A. 1989. The Historical Dimension in Mortuary Expressions of Status and Sentiment. *Current Anthropology,* 30**,** 437-458.

CARLSON, D.S., ARMELAGOS, G.J. & VAN GERVEN, D.P. 1974. Factors Influencing the Etiology of Cribra Orbitalia in Prehistoric Nubia. *Journal of Human Evolution,* 3**,** 405-410.

CARR, C. 1995. Mortuary Practices: Their Social, Philosophical-Religious, Circumstantial, and Physical Determinants. *Journal of Archaeological Method and Theory,* 2**,** 105-200.

CAUSEY, F. 2012. *Amber and the Ancient World,* Los Angeles, J. Paul Getty Museum.

CAWTE, H.J. & BOYD, W.E. 2010. Laterite Nodules: A Credible Source of Iron Ore in Iron Age Northeast Thailand? *Geoarchaeology,* 25**,** 626-644.

CHANG, N. 2001. *Personal Ornaments in Thai Prehistory: Nong nor, Ban Lum Khao and Noen U-Loke.* Doctor of Philosophy, University of Otago.

CHANG, N.J. 2004. The Personal Ornaments. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department, 217-230.

CHANG, N.J. 2007. The Shell, Silver, Gold, Bronze and Bone Personal Ornaments. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 379-430.

CHETWIN, J.N. 2007. The Remains of Wattle and Daub Structures. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 447-464.

CHRISTENSON, A.L. (ed.) 1989. *Tracing Archaeology's Past: The Historiography of Archaeology*: Southern Illinois University Press.

CLARKE, D.L. 1968. *Analytical Archaeology,* London, Methuen.

COHEN, M. & ARMELAGOS, G. 1984. *Paleopathology at the Origins of Agriculture,* Orlando, Academic Press.

COHEN, M.N. & CRANE-KRAMER, G.M.M. 2007. *Ancient Health: Skeletal Indicators of Agricultural and Economic Intensification,* University Press of Florida.

CONNELLY, R. 2007. The Iron and Bimetallic Artefacts. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 431-446.

COX, K.J., BENTLEY, R.A., TAYLES, N., BUCKLEY, H.R., MACPHERSON, C.G. & COOPER, M.J. 2011. Intrinsic or Extrinsic Population Growth in Iron Age Northeast Thailand? The Evidence from Isotopic Analysis. *Journal of Archaeological Science,* 38**,** 665-671.

COX, M. 2000. Aging Adults from the Skeleton. *In:* M. COX, S.M. (ed.) *Human Osteology in Archaeology and Forensic Science.* London: Greenwich Medical Media, 61-81.

CREAMER, W. & HAAS, J. 1985. Tribe Versus Chiefdom in Lower Central America. *American Antiquity,* 50**,** 738-754.

CRUMLEY, C.L. 1995. Heterarchy and the Analysis of Complex Societies. *Archeological Papers of the American Anthropological Association,* 6**,** 1-5.

CUCINA, A. & TIESLER, V. 2003. Dental Caries and Antemorten Tooth Loss in the Northern Peten Area, Mexico: A Biocultural Perspective on Social Status Differences among the Classic Maya. *American Journal of Physical Anthropology,* 122**,** 1-10.

CUCINA, A., VARGIU, R., MANCINELLI, D., RICCI, R., SANTADREA, E., CATALANO, P. & COPPA, A. 2006. The Necropolis of Vallerano (Rome, 2nd–3rd Century A.D.): An Anthropological Perspective on the Ancient Romans in the Suburbium. *International Journal of Osteoarchaeology,* 16**,** 104-117.

CYBULSKI, J.S. 1977. Cribra Orbitalia as a Possible Sign of Anaemia in Early Historic Native Population of the British Columbia Coast. *American Journal of Physical Anthropology,* 47**,** 31-40.

DANIFORTH, M.E. 1999. Nutrition and Politics in Prehistory. *Annual Review of Anthropology,* 28**,** 1-25.

DAVID, R. 2002. *Religion and Magic in Ancient Egypt,* London, Penguin Books Limited.

DEANE, P. 1979. *The First Industrial Revolution,* 2d, Cambridge, Cambridge University Press.

DEMETER, F., PEYRE, E. & COPPENS, Y. 2002. The Prehistoric Human Remains of Som Ron Sen, Cambodia. *Indo Pacific Prehistoric Association Bulletin,* 22**,** 135-140.

DETER, C.A. 2009. Gradients of Occlusal Wear in Hunter-Gatherers and Agriculturalists. *American Journal of Physical Anthropology,* 138**,** 247-254.

DETTWYLER, K.A. 1991. Can Paleopathology Provide Evidence for "Compassion"? *American Journal of Physical Anthropology,* 84**,** 375-384.

DIAS, G. & TAYLES, N. 1997. 'Abscess Cavity' - a Misnomer. *International Journal of Osteoarchaeology,* 7**,** 548-554.

DÍAZ-ANDREU, M. 2005. Gender Identity. *In:* DÍAZ-ANDREU, M., LUCY, S., BABIĆ, S. & EDWARDS, D. (eds.) *The Archaeology of Identity: Approaches to Gender, Age, Status, Ethnicity and Religion.* London: Routledge, 13-42.

DIEKHOFF, G. 1992. *Statistics for the Social and Behavioural Sciences: Univariate, Bivariate, Multivariate,* Dubuque, Wm.C. Brown.

DOBRES, M.-A. 1995. Gender and Prehistoric Technology: On the Social Agency of Technical Strategies. *World Archaeology,* 27**,** 25-49.

DOBRES, M.A. & ROBB, J. (eds.) 2000. *Agency in Archaeology,* London: Routledge.

DOMETT, K. 2001. *Health in Late Prehistoric Thailand,* Oxford, Archaeopress.

DOMETT, K. 2004. The People of Ban Lum Khao. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department, 113-158.

DOMETT, K. 2005. Phum Snay Skeletal Analysis, Cambodia. *Southeast Asia Bioarchaeology Newsletter.*

DOMETT, K. & TAYLES, N. 2006. Human Biology from the Bronze Age to Iron Age in the Mun River Valley in Northeast Thailand. *In:* M. OXENHAM, N.T. (ed.) *Bioarchaeology of Southeast Asia.* Cambridge: Cambridge University Press, 220-240.

DOMETT, K.M. & BUCKLEY, H.R. 2012. Large Lytic Cranial Lesions: A Differential Diagnosis from Pre-Angkorian Cambodia. *International Journal of Osteoarchaeology,* 22**,** 731-739.

DOMETT, K.M., NEWTON, J., O'REILLY, D.J.W., TAYLES, N., SHEWAN., L. & BEAVAN, N. 2013. Cultural Modification of the Dentition in Prehistoric Cambodia. *International Journal of Osteoarchaeology,* 23**,** 274-286.

DOMETT, K.M. & O'REILLY, D.J.W. 2009. Health in Pre-Angkorian Cambodia: A Bioarchaeological Analysis of the Skeletal Remains from Phum Snay. *Asian Perspectives,* 48**,** 56-78.

DOMETT, K.M., O'REILLY, D.J.W. & BUCKLEY, H.R. 2011. Bioarchaeological Evidence for Conflict in Iron Age North-West Cambodia. *Antiquity,* 85**,** 441-458.

DOMETT, K.M. & TAYLES, N. 2006. Adult Fracture Patterns in Prehistoric Thailand: A Biocultural Interpretation. *International Journal of Osteoarchaeology,* 16**,** 185-199.

DONHAM, K.J. & THELIN, A. 2006. *Agricultural Medicine : Occupational and Environmental Health for the Health Professions,* 1st ed., Ames, Iowa ; Oxford, Blackwell.

DOUGLAS, M.T. 1996a. Non Nok Tha Databases 1-10, (Web Ver 1.0 at Http://Seasia.Museum.Upenn.Edu/Skeletal/), in Paleopathology in Human Skeletal Remains from the Pre-Metal, Bronze, and Iron Ages, Northeastern Thailand. Unpublished Ph.D. Dissertation, Department of Anthropology, University of Hawaii, Honolulu.

DOUGLAS, M.T. 1996b. *Paleopathology in Human Skeletal Remains from the Pre-Metal, Bronze and Iron Ages, Northeastern Thailand.* PhD, University of Hawaii.

DOUGLAS, M.T. 2006. Subsistence Change an Dental Health in the People of Non Nok Tha. *In:* M. OXENHAM, N.T. (ed.) *Bioarchaeology of South East Asia.* Cambridge: Cambridge University Press, 119-219.

DRENNAN, R.D. & PETERSON, C.E. 2006. Patterned Variation in Prehistoric Chiefdoms. *Proceedings of the National Academy of Sciences of the United States of America,* 103**,** 3960-3967.

DUKE, B.J., CARTER, A.K. & CHANG, N.J. 2010. The Excavation of Iron Age Working Floors and Small-Scale Industry at Ban Non Wat, Thailand. *Papers from the Institute of Archaeology,* 20**,** 123.

DUNN, F.L. 1970. Cultural Evolution in the Late Pleistocene and Holocene of Southeast Asia. *American Anthropologist,* 72**,** 1041-1054.

DURIC, M., RAKOCEVIC, Z. & DONIC, D. 2005. The Reliability of Sex Determination of Skeletons from Forensic Context in the Balkans. *Forensic Science International,* 147**,** 159-164.

EARLE, T.K. 1987. Chiefdoms in Archaeological and Ethnohistorical Perspective. *Annual Review of Anthropology,* 16**,** 279-308.

EASTERLIN, R.A. 1995. Industrial Revolution and Mortality Revolution: Two of a Kind? *Journal of Evolutionary Economics,* 5**,** 393-408.

EL-NAJJAR, M.Y., RYAN, D.J., TURNER, G. & LOZOFF, B. 1976. The Etiology of Porotic Hyperstosis among the Prehistoric and Historic Anasazi Indians of Southwestern United States. *American Journal of Physical Anthropology,* 44**,** 477-487.

EMBER, C.R. 1978. Myths About Hunter-Gatherers. *Ethnology,* 17**,** 439-448.

EVELITH, P.B. & TANNER, J.M. 1990. *Worldwide Variation in Human Growth,* Cambridge, Cambridge University Press.

FACCHINI, F., RASTELLI, E. & BRASILI, P. 2004. Cribra Orbitalia and Cribra Cranii in Roman Skeletal Remains from the Ravenna Area and Rimini (I-I.V. Century A.D.). *International Journal of Osteoarchaeology,* 14**,** 126-136.

FAGAN, B. 1992. *People of the Earth: An Introduction to World Prehistory,* New York, Harper Collins.

FALYS, C.G., SCHUTKOWSKI, H. & WESTON, D.A. 2006. Auricular Surface Aging: Worse Than Expected? A Test of the Revised Method on a Documented Historic Skeletal Assemblage. *American Journal of Physical Anthropology,* 130**,** 508-513.

FEJERSKOV, O. & KIDD, E. 2008. *Dental Caries: The Disease and Its Clinical Management,* Oxford, Blackwell Munksgaard.

FLANAGAN, J.G. 1989. Hierarchy in Simple "Egalitarian" Societies. *Annual Review of Anthropology,* 18**,** 245-266.

FLANNERY, K.V. 1972. The Cultural Evolution of Civilizations. *Annual Review of Ecology and Systematics,* 3**,** 399-426.

FLOYD, B. & LITTLETON, J. 2006. Linear Enamel Hypoplasia and Growth in an Australian Aboriginal Community: Not So Small, but Not So Healthy Either. *Annals of Human Biology,* 33**,** 424-443.

FORBES, R.J. 1964. *Studies in Ancient Technology,* 2nd, Leiden, E.J. Brill.

FOX, J. & LEDGERWOOD, J. 1999. Dry Season Flood Recession Rice in the Mekong Delta: Two Thousand Years of Sustainable Agriculture? *Asian Perspectives,* 38**,** 37-50.

FRIED, M.H. 1967. *The Evolution of Political Society: An Essay in Political Anthropology,* New York, Random House.

GAGE, T.B. 1988. Mathematical Hazard Models and Mortality: An Alternative to Model Life Tables. *American Journal of Physical Anthropology,* 76**,** 429-441.

GAMBLE, L.H., WALKER, P.L. & RUSSELL, G.S. 2001. An Integrative Approach to Mortuary Analysis: Social and Symbolic Dimensions of Chumas Burial Practices. *American Antiquity,* 66**,** 185 - 212.

GARG, N. & GARG, A. 2010. *Textbook of Operative Dentistry,* New Delhi, Jaypee Brothers, Medical Publishers.

GIBBON, G. 1984. *Anthropological Archaeology,* New York, Columbia University Press.

GILBERT, B.M. & MCKERN, T.W. 1973. A Method for Aging the Female Os Pubis. *American Journal of Physical Anthropology,* 38**,** 31-38.

GILMAN, A. 1981. The Development of Social Stratification in Bronze Age Europe. *Current Anthropology,* 22**,** 1-23.

GJERDRUM, T., WALKER, P.L., BATHURST, R.R., RICHMAN, R. & ANDRUSHKO, V.A. 2008. The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anaemia Hypothesis. *17th European Meeting of the Paleopathology Association.* Copenhagen.

GOODMAN, A.H. 1993. On the Interpretation of Health from Skeletal Remains. *Current Anthropology,* 34**,** 281-288.

GOODMAN, A.H. & ARMELAGOS, G.J. 1989. Infant Morbidity and Mortality Risks in Archaeological Populations. *World Archaeology,* 21**,** 225-243.

GOODMAN, A.H. & MARTIN, D.L. 2002. Reconstructing Health Profiles from Skeletal Remains: Health and Nutrition in the Western Hemisphere. *In:* STECKEL, R.H. & ROSE, J.C. (eds.) *The Backbone of History.* Cambridge: Cambridge University Press, 11-60.

GOODMAN, A.H., THOMAS, R.B., SWEDLUND, A.C. & ARMELAGOS, G.J. 1988. Biocultural Persepectives on Stress in Prehistoric, Historical, and Contemporary Research Population Research. *Yearbook of Physical Anthropology,* 31**,** 169-202.

GOODY, J. 2004. *Death and the Ancestors: A Study of the Mortuary Customs of the Lodagaa of West Africa,* London, Routledge.

GOOGLE. 20 October 2013a. *Ban Non Wat. Thailand*. maps.google.com.au: Google Maps.

GOOGLE. 20 October 2013b. *Noen U-Loke, Thailand*. maps.google.com.au: Google Earth.

GORING, E. 1989. Death in Everyday Life: Aspects of Burial Practice in the Late Bronze Age. *In:* PELTENBERG, E. (ed.) *Early Society in Cyprus.* Edinburgh: Edinburgh University Press, 95-105.

GOWLAND, R.L. & CHAMBERLAIN, A.T. 2005. Detecting Plague: Palaeodemographic Characterisation of a Catastrophic Death Assemblage. *Antiquity,* 79**,** 146-157.

GRAUER, A.L. & ROBERTS, C.A. 1996. Paleoepidemiology, Healing, and Possible Treatment of Trauma in the Medieval Cemetery Population of St. Helen-on-the-Walls, York, England. *American Journal of Physical Anthropology,* 100**,** 531-544.

GROPPER, S.S., SMITH, J.L. & GROFF, J.L. 2009. *Advanced Nutrition and Human Metabolism,* Belmont, Wadsworth.

HAIDLE, M.N. 2001. Fragments of Glass Bangles from Krek 52/62 and Their Implications for the Dating of the Mimotien Culture. *Asian Perspectives,* 40**,** 195-208.

HALCROW, S.E. 2006. *Subadult Health and Disease in Late Prehistoric Mainland Southeast Asia.* PhD, University of Otago.

HALCROW, S.E., TAYLES, N. & BUCKLEY, H.R. 2007. Age Estimation of Children from Prehistoric Southeast Asia: Are the Dental Formation Methods Used Appropriate? *Journal of Archaeological Science,* 34**,** 1158-1168.

HARRIS, N.J. 2010. *Disposing of the Dead: An Investigation into Prehistoric Mortuary Practices During the Neolithic and Bronze Ages at Ban Non Wat, Thailand.* Master of Science University of Otago.

HAVELKOVÁ, P., HLADÍK, M. & VELEMÍNSKÝ, P. 2013. Entheseal Changes: Do They Reflect Socioeconomic Status in the Early Medieval Central European Population? (Mikulčice – Klášteřisko, Great Moravian Empire, 9th – 10th Century). *International Journal of Osteoarchaeology,* 23**,** 237-251.

HAWKEY, D.E. 1998. Disability, Compassion and the Skeletal Record: Using Musculoskeletal Stress Markers (M.S.M.) to Construct an Osteobiography from Early New Mexico. *International Journal of Osteoarchaeology,* 8**,** 326-340.

HAYDEN, B. 2001. The Dynamics of Wealth and Poverty in the Transegalitarian Societies of Southeast Asia. *Antiquity,* 75**,** 571-581.

HAYDEN, B. 2007. Richman, Poorman, Beggarman, Chief: The Dynamics of Social Inequality. *In:* FEINMAN, G.M. & PRICE, T.D. (eds.) *Archaeology at the Millennium: A Sourcebook.* New York: Springer, 231-272.

HAYDEN, B. 2009. Funerals as Feasts: Why Are They So Important? *Cambridge Archaeological Journal,* 19**,** 29-52.

HAYS, K.A. 1993. When Is a Symbol Archaeologically Meaningful?: Meaning, Function, and Prehistoric Visual Arts. *In:* N. YOFFEE, A.S. (ed.) *Archaeological Theory: Who Sets the Agenda?* Cambridge: Cambridge University Press, 81-92.

HEGMON, M. 2003. Setting Theoretical Egos Aside: Issues and Theory in North American Archaeology. *American Antiquity,* 68**,** 213-243.

HEGMON, M. 2005. No More Theory Wars: A Response to Moss. *American Antiquity,* 70**,** 588-590.

HIGHAM, C. 1996. *The Bronze Age of Southeast Asia,* Cambridge, Cambridge University Press.

HIGHAM, C. 2001. *The Civilization of Angkor,* London, The Orion Publishing Group.

HIGHAM, C. 2002. *Early Cultures of Mainland South-East Asia,* Bangkok, River Books.

HIGHAM, C. & HIGHAM, T. 2009. A New Chronological Framework for Prehistoric Southeast Asia, Based on a Bayesian Model from Ban Non Wat *Antiquity,* 83**,** 125-144.

HIGHAM, C. & KIJNGAM, A. 1984a. The Mortuary Ritual at Ban Na Di. *In:* HIGHAM, C. & KIJNGAM, A. (eds.) *Prehistoric Investigations in Northeast Thailand.* Oxford: BAR,

HIGHAM, C. & KIJNGAM, A. 1984b. *Prehistoric Investigations in Northeast Thailand,* Oxford, BAR.

HIGHAM, C. & KIJNGAM, A. 2012. The Origins of the Civilization of Angkor, Volume V : The Excavation of Ban Non Wat: The Bronze Age. Havertown: Fine Arts Department of Thailand.

HIGHAM, C. & KIJNGAM, A. (eds.) 2013. *The Origins of the Civilization of Angkor, Volume 6 : The Iron Age: Summary and Conclusions,* Havertown: Fine Arts Department of Thailand.

HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) 2007. *The Excavation of Noen U-Loke and Non Muang Kao,* Bangkok: The Thai Fine Arts Department.

HIGHAM, C. & THOSARAT, R. 2000. The Origins of the Civilization of Angkor. *Antiquity,* 74**,** 27-28.

HIGHAM, C. & THOSARAT, R. 2006. Ban Non Wat: The First Three Seasons. *In:* BACUS, E.A., GLOVER, I.C. & PIGOTT, V.C. (eds.) *Uncovering Southeast Asia's Past: 10th International Conference of the European Association of Southeast Asian Archaeologists.* Singapore: NUS Press, 98-104.

HIGHAM, C.F.W. 1998. The Transition from Prehistory to the Historic Period in the Upper Mun Valley. *International Journal of Historical Archaeology,* 2**,** 235-260.

HIGHAM, C.F.W. 2006. Report to the National Research Council of Thailand: The Development of an Iron Age Chiefdom.

HIGHAM, C.F.W. 2007a. The Material Culture. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Origins of the Civilization of Angkor: The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department,

HIGHAM, C.F.W. 2007b. Summary and Conclusions. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 595-610.

HIGHAM, C.F.W. 2011. The Bronze Age of Southeast Asia: New Insight on Social Change from Ban Non Wat. *Cambridge Archaeological Journal,* 21**,** 365-389.

HIGHAM, C.F.W. & O'REILLY, D.J.W. 2004. Social Aspects of the Ban Lum Khao Cemetery. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department 301-323.

HIGHAM, C.F.W. & THOSARAT, R. 1998. *The Excavation of Nong Nor,* Dunedin, University of Otago.

HIGHAM, C.F.W. & THOSARAT, R. 2004a. The Burials from Mortuary Phase 1. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department, 23-32.

HIGHAM, C.F.W. & THOSARAT, R. (eds.) 2004b. *The Excavation of Ban Lum Khao,* Bangkok: Fine Arts Department.

HIGHAM, C.F.W. & THOSARAT, R. 2004c. The Excavation, Stratigraphy, Spatial Variables and Chronology. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Fine Arts Department of Thailand, 1-22.

HIGHAM, C.F.W. & THOSARAT, R. 2007a. The Burials of Mortuary Phases 1 and 2. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Origins of the Civilization of Angkor: The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 143-152.

HIGHAM, C.F.W. & THOSARAT, R. 2007b. Introduction: The Stratigraphy and Radiocarbon Chronology. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 75-84.

HILLSON, S. 2000. Dental Pathology. *In:* M.A. KATZENBERG, S.R.S. (ed.) *Biological Anthropology of the Human Skeleton.* New York: J. Wiley & Sons, 249-286.

HILLSON, S. 2001. Recording Dental Caries in Archaeological Human Remains. *International Journal of Osteoarchaeology,* 11**,** 249 - 289.

HILLSON, S. & BOND, S. 1997. Relationship of Enamel Hypoplasia to the Pattern of Tooth Crown Growth: A Discussion. *American Journal of Physical Anthropology,* 104**,** 89 -103.

HINTON, R.J. 1981. Form and Patterning of Anterior Tooth Wear among Aboriginal Human Groups. *American Journal of Physical Anthropology,* 54**,** 555-564.

HLAING, T., RAMTEKE, S. & BINYMIN, K. 2009. Gold Finger: Metal Jewellery as a Disease Modifying Antirheumatic Therapy! *Case reports in medicine* [Online], 2009.

HODDER, I. 1991. *Reading the Past: Current Approaches to Interpretation in Archaeology,* 2nd, Cambridge, Cambridge University Press.

HODGES, D.C. 1987. Health and Agricultural Intensification in the Prehistoric Valley of Oaxaca, Mexico. *American Journal of Physical Anthropology,* 73 323-332.

HOLLAND, T.D. & O'BRIEN, M.J. 1997. Parasites, Porotic Hyperostosis, and the Implications of Changing Perspectives. *American Antiquity,* 62**,** 183-193.

HONAN, Z.E. 2005. *The Caries of Phum Snay.* Honours, James Cook University.

HOUGHTON, P. & WIRIYAROMP, W. 1984. The People of Ban Na Di: Part 2. *In:* HIGHAM, C. & KIJNGAM, A. (eds.) *Prehistoric Investigations in Northeastern Thailand.* Oxford: BAR, 391-411.

HUMPHREY, L. 2000. Growth Studies of Past Populations: And Overview and an Example. *In:* COX, M. & MAYS, S. (eds.) *Human Osteology in Archaeology and Forensic Science.* London: Greenwich Medical Media, 23-38.

IŞCAN, M.Y. & DING, S. 1995. Sexual Dimorphism in the Chinese Femur. *Forensic Science International,* 74**,** 79-87.

IŞCAN, M.Y. & KEDICI, P.S. 2003. Sexual Variation in Bucco-Lingual Dimensions in Turkish Dentition. *Forensic Science International,* 137**,** 160-164.

JACKES, M., LUBELL, D. & MEIKLEJOHN, C. 1997. Healthy but Mortal: Human Biology and the First Farmers of Western Europe. *Antiquity,* 71**,** 639-658.

JACOBI, K.P. & DANIFORTH, M.E. 2002. Analysis of Interobserver Scoring Patterns in Porotic Hyperostosis and Cribra Orbitalia. *International Journal of Osteoarchaeology,* 12**,** 248-258.

JACOBSON, H.S., PIERSON, C.T., DANUSAWAD, T., JAPAKASETR, T., INTHUPUTI, B., SIRIRATANAMONGKOL, C., PRAPASSORNKUL, S. & PHOLPHAN, N. 1969. *Mineral Investigations in Northeastern Thailand,* Washington, United States Gonvernment Printing Office.

JANKAUSKAS, R. 2003. The Incidence of Diffuse Idiopathic Skeletal Hypertosis and Social Status Correlations in Lithuanian Skeletal Materials. *International Journal of Osteoarchaeology,* 13**,** 289-293.

JONUKS, T. 2005. Archaeology of Religion - Possibilities and Prospects. *Estonian Journal of Archaeology,* 9**,** 32-56.

JURMAIN, R. 1990. Paleoepidimiology of a Central California Prehistoric Population. From Ca-Ala-329: 2 Degenerative Diseases. *American Journal of Physical Anthropology,* 83**,** 83-94.

JURMAIN, R.D. 1977. Stress and the Etiology of Osteoarthritis. *American Journal of Physical Anthropology,* 46**,** 353-365.

KALLEN, A. 2004. *An through Flows the River: Archaeology and the Pasts of Lao Pako,* Uppsala University.

KALLIO, V. 1982. Medical and Social Problems of the Disabled. *EURO Reports and Studies.* Copenhagen: World Health Organization.

KAMP, K.A. 1998. Social Hierarchy and Burial Treatments: A Comparative Assessment. *Cross-Cultural Research,* 32**,** 79-115.

KARLSTROM, A. 2000. Lao Pako, an Iron Age Site on the Nam Ngum River in Laos. *Indo Pacific Prehistoric Association Bulletin,* 19 85-92.

KESWANI, P.S. 2005. Death, Prestige and Copper in Bronze Age Cyprus. *American Journal of Archaeology,* 109**,** 341-401.

KIESER, J.A., PRESTON, C.B. & EVANS, W.G. 1983. Skeletal Age at Death: An Evaluation of the Miles Method of Aging. *Journal of Archaeological Sciences,* 10**,** 9-12.

KIJNGAM, A., HIGHAM, C. & WIRIYAROMP, W. 1980. *Prehistoric Settlement Patterns in Northeast Thailand: The Result of Site Surveys Undertaken in January and February 1980,* Dept. of Anthropology, University of Otago.

KIM, J.M., STEWART, R., PRINCE, M., KIM, S.W., YANG, S.J., SHIN, I.S. & YOON, J.S. 2007. Dental Health, Nutritional Status and Recent-Onset Dementia in a Korean Community Population. *International Journal of Geriatric Psychiatry,* 22**,** 850-855.

KIM, S. 1994. Burials, Pigs and Political Prestige in Neolithic China. *Current Anthropology,* 35**,** 119-141.

KING, C.A. 2006. *Paleodietary Change among Pre-State Metal Age Societies in Northeast Thailand: A Stable Isotope Approach.* PhD, University of Hawaii.

KING, C.A. & NORR, L. 2006. Paleodietary Change among Pre-State Metal Age Societies in Northeast Thailand: A Study Using Bone Stable Isotopes. *In:* OXENHAM, M. & TAYLES, N. (eds.) *Bioarchaeology of Southeast Asia.* Cambridge: Cambridge University Press, 241-262.

KING, C.L., BENTLEY, R.A., TAYLES, N., VIÐARSDÓTTIR, U.S., NOWELL, G. & MACPHERSON, C.G. 2013. Moving Peoples, Changing Diets: Isotopic Differences Highlight Migration and Subsistence Changes in the Upper Mun River Valley, Thailand. *Journal of Archaeological Science,* 40**,** 1681-1688.

KJELLSTRÖM, A., TESCH, S. & WIKSTROM, A. 2005. Inhabitants of a Sacred Landscape: An Archaeological and Osteological Analysis of Skeletal Remains from Late Viking Age and Medieval Sigtuna, Sweden. *Acta Archaeologia,* 76**,** 87-110.

KNUDSON, K.J. & STOJANOWSKI, C.M. 2008. New Directions in Bioarchaeology: Recent Contributions to the Study of Human Social Identities. *Journal of Archaeological Research,* 16**,** 397-432.

KUETTNER, K. & GOLDBERG, V.M. 1995. Introduction. *In:* KUETTNER, K. & GOLDBERG, V.M. (eds.) *Osteoarthritic Disorders.* Rosemont: American Academy of Orthopaedic Surgeons, xxi-v.

LARSEN, C.S. 1983. Behavioural Implications of Temporal Change in Cariogenesis. *Journal of Archaeological Science,* 10**,** 1-8.

LARSEN, C.S. 1995. Biological Changes in Human Populations with Agriculture. *Annual Review of Anthropology,* 24**,** 185-213.

LARSEN, C.S. 1997. *Bioarchaeology: Interpreting Behaviour from the Human Skeleton,* Cambridge, Cambridge University Press.

LAWRENCE, A.J. 1971. Early Neolithic Skeletons from Çatal Hüyük: Demography and Pathology *Anatolian Studies,* 21**,** 77-98.

LEE, G.Y. & TAPP, N. 2010. *Culture and Customs of the Hmong,* Santa Barbara, ABC-CLIO.

LEE, R.B. 1979. *The !Kung San,* Cambridge, Cambridge University Press.

LEE, Y.K. 1994. Comment. *Current Anthropology,* 35**,** 133-135.

LERTRIT, P., POOLSUWAN, S., THOSARAT, R., SANPACHUDAYAN, T., BOONYARIT, H., CHINPAISAL, C. & SUKTITIPAT, B. 2008. Genetic History of Southeast Asian Populations as Revealed by Ancient and Modern Human Mitochondrial DNA Analysis. *American Journal of Physical Anthropology,* 137**,** 425-440.

LEWIS, M. 2000. Non-Adult Paleopathology: Current Status and Future Potential. *In:* M. COX, S.M. (ed.) *Human Osteology in Archaeology and Forensic Science.* London: Greenwich Medical Media, 39-57.

LEWIS, M.E. 2004. Endocranial Lesions in Non-Adult Skeletons: Understanding Their Aetiology. *International Journal of Osteoarchaeology,* 14**,** 82-97.

LIEBERMAN, D.E. 1996. How and Why Humans Grow Thin Skulls: Experimental Evidence for Systemic Cortical Robusticity. *American Journal of Physical Anthropology,* 101**,** 217-236.

LIEVERSE, A.R., WEBER, A.W. & GORIUNOVA, O.I. 2006. Human Taphonomy at Khuzhir-Nuge Xiv, Siberia: A New Method for Documenting Skeletal Condition. *Journal of Archaeological Science,* 33**,** 1141-1151.

LINGSTROM, P. 1993. *On the Cariogenic Potential of Starch,* Goteborg, University of Goteborg.

LOKURUKA, M. 2006. Meat Is the Meal and Status Is by Meat: Recognition of Rank, Wealth, and Respect through Meat in Turkana Culture. *Food & Foodways,* 14**,** 201-229.

LOVEJOY, C.O., MEINDL, R.S., MENSFORTH, R.P. & BARTON, T.J. 1985a. Multifactorial Determination of Skeletal Age at Death: A Method and Blind Tests of Its Accuracy. *American Journal of Physical Anthropology,* 68**,** 1-14.

LOVEJOY, C.O., MEINDL, R.S., PRYZBECK, T.R. & MENSWORTH, R.P. 1985b. Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for Determination of Age of Adult Skeletal Age at Death. *American Journal of Physical Anthropology,* 68**,** 15 - 28.

LOVELL, N.C. 1997. Trauma Analysis in Paleopathology. *Yearbook of Physical Anthropology,* 40**,** 139-170.

LOVELL, N.C. 2000. Paleopathological Description and Diagnosis. *In:* M.A. KATZENBERG, S.R.S. (ed.) *Biological Anthropology of the Human Skeleton.* New York: J. Wiley & Sons, 217-248.

LUBELL, D., JACKES, M., SCHWARCZ, H., KNYF, M. & MEIKLEJOHN, C. 1994. The Mesolithic-Neolithic Transition in Portugal: Isotopic and Dental Evidence of Diet. *Journal of Archaeological Science,* 21**,** 201-216.

LUKACS, J.R. 2007. Dental Trauma and Antemortem Tooth Loss in Prehistoric Canary Islanders: Prevalence and Contributing Factors. *International Journal of Osteoarchaeology,* 17**,** 157-173.

LUKACS, J.R. 2008. Fertility and Agriculture Accentuate Sex Differences in Dental Caries Rates. *Current Anthropology,* 49**,** 901-914.

LUKACS, J.R. 2011. Sex Differences in Dental Caries Experience: Clinical Evidence, Complex Etiology. *Clinical Oral Investigations,* 15**,** 649-656.

LUKACS, J.R. & LARGAESPADA, L.L. 2006. Explaining Sex Differences in Dental Caries Prevalence: Saliva, Hormones, and "Life-History" Etiologies. *Am J Hum Biol,* 18**,** 540-555.

LULL, V. 2000. Death and Society: A Marxist Approach. *Antiquity,* 74**,** 576-580.

LYMAN, R.L. 1994. *Vertebrate Taphonomy,* Cambridge, Cambridge University Press.

LYNCH, J.W., KAPLAN, G.A., COHEN, R.D., KAUHANEN, J., WILSON, T.W., SMITH, N.L. & SALONEN, J.T. 1994. Childhood and Adult Socioeconomic Status as Predictors of Mortality in Finland. *Lancet,* 343**,** 524-7.

LYNCH, J.W., KAPLAN, G.A. & SALONEN, J.T. 1997. Why Do Poor People Behave Poorly? Variation in Adult Health Behaviours and Psychosocial Characteristics by Stages of the Socioeconomic Lifecourse. *Soc Sci Med,* 44**,** 809-819.

MAAT, G.J.R. 2005. Two Millennia of Male Stature Development and Population Health in the Low Countries. *International Journal of Osteoarchaeology,* 15**,** 276-290.

MAAT, G.J.R. & E.A. VAN DER VELDE 1987. The Caries-Attrition Competition. *International Journal of Anthropology,* 2**,** 281-292.

MACDONALD, D.H. 2001. Grief and Burial in the American Southwest: The Role of Evolutionary Theory in the Interpretation of Mortuary Remains. *American Antiquity,* 66**,** 704-714.

MALLERET, L. 1959. Ouvrages Circulaires En Terre Dans L'indochine Méridionale. *Bulletin de l'Ecole française d'Extrême-Orient,* 49**,** 409-434.

MANACH, C., SCALBERT, A., MORAND, C., RÉMÉSY, C. & JIMÉNEZ, L. 2004. Polyphenols: Food Sources and Bioavailability. *The American Journal of Clinical Nutrition,* 93**,** 727-747.

MANN, R.W. & HUNT, D.R. 2005. *Photographic Regional Atlas of Bone Disease: A Guide to Pathologic and Normal Variation in the Human Skeleton,* Springfield, Charles C. Thomas.

MAPSON, R. 2008. *A Dental Pathology Profile of Southeast Asia: A Bioarchaeological Case Study from Pre-Angkorian Phum Snay, Cambodia.* Bachelor of Science, James Cook University.

MARMOT, M.G. 1986. *Social Inequalities in Mortality: The Social Environment,* London, Tavistock Publications.

MARTRILLE, L., UBELAKER, D.H., CATTANEO, C., SEGURET, F., TREMBLAY, M. & BACCINO, E. 2007. Comparison of Four Skeletal Methods for the Estimation of Age at Death on White and Black Adults. *Journal of Forensic Sciences,* 52**,** 302-307.

MAYES, A.T. & BARBER, S.B. 2008. Osteobiography of a High-Status Burial from the Lower Río Verde Valley of Oaxaca, Mexico. *International Journal of Osteoarchaeology,* 18**,** 573-588.

MAYHALL, J.T. 2000. Dental Morphology, Techniques and Strategies. *In:* M.A. KATZENBERG, S.R.S. (ed.) *Biological Anthropology of the Human Skeleton.* New York: J. Wiley & Sons, 103-134.

MAYS, S. 1998. *The Archaeology of Human Bones,* London, Routledge.

MAYS, S., DELARUA, C. & MOLLESON, T. 1995. Molar Crown Height as a Means of Evaluating Existing Dental Wear Scales for Estimating Age at Death in Human Skeletal Remains. *Journal of Archaeological Sciences,* 22**,** 659-670.

MCCAW, M. 2007. Faunal Remains: Results and Conclusions. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 513-520.

MCGRATH, R.J. & BOYD, W.E. 2000. The Chronology of the Iron Age 'Moats' of Northeast Thailand. *Antiquity,* 75**,** 349-360.

MCGRATH, R.J., BOYD, W.E. & BUSH, R.T. 2008. The Paleohydrological Context of the Iron Age Floodplain Sites of the Mun River Valley, Northeast Thailand. *Geoarchaeology,* 23**,** 151-172.

MCGUIRE, R.H. 1993. Archaeology and Marxism. *In:* SCHIFFER, M.B. (ed.) *Archaeological Method and Theory.* Tucson: The University of Arizona Press, 101-157.

MEIKLEJOHN, C., WYMAN, J.M. & SCHENTAG, C.T. 1992. Caries and Attrition: Dependent or Independent Variables? *International Journal of Anthropology,* 7**,** 17-22.

MEINDL, R.S. & LOVEJOY, C.O. 1985. Ectocranial Suture Closure: A Revised Method for the Determination of Skeletal Age at Death Based on the Laterial-Anterior Sutures. *American Journal of Physical Anthropology,* 68**,** 57-66.

MEZA, R.S. 2003. Radiographic Assessment of Congenitally Missing Teeth in Orthodontic Patients. *International Journal of Paediatric Dentistry,* 13**,** 112-116.

MILES, A.E.W. 1963a. The Dentition in the Assessment of Individual Age in Skeletal Material. *In:* BROTHWELL, D.R. (ed.) *Dental Anthropology.* New York: Pergamon Press, 191-208.

MILES, A.E.W. 1963b. Dentition in the Estimation of Age. *Journal of Dental Research,* 42**,** 255-263.

MILES, A.E.W. 2001. The Miles Method of Assessing Age from Tooth Wear Revisted. *Journal of Archaeological Sciences,* 28**,** 973-982.

MILNER, G.R. 1984. Social and Temporal Implications of Variation among American Bottom Mississippian Cemeteries. *American Antiquity,* 49**,** 468 - 488.

MOLNAR, P. & KJELLSTRÖM, A. Skeletal Evidence of Health, Disease and Activity in Two Swedish Populations. 17th European Meeting of the Paleopathological Association "Diseases of the Past", 2008 Copenhagen.

MOLNAR, S. 1971. Human Tooth Wear, Tooth Function and Cultural Variability. *American Journal of Physical Anthropology,* 34**,** 175-189.

MOLNAR, S. & MOLNAR, I. 1985. Observations of Dental Disease among Prehistoric Populations of Hungary. *American Journal of Physical Anthropology,* 67**,** 51-63.

MOOREY, P.R.S. 1994. *Ancient Mesopotamian Materials and Industries: The Archaeological Evidence,* Oxford, Clarendon Press.

MURPHY, A.M.C. 2005. The Femoral Head: Sex Assessment of Prehistoric New Zealand Polynesian Skeletal Remains. *Forensic Science International,* 154**,** 210-213.

MUTH, S.M. 2003. *Health and Wealth: An Investigation of Social Status and Biological Status at the Iron Age Settlement of Noen U-Loke.* BA (Hons), University of Otago.

NAGAOKA, T., HIRATA, K., YOKOTA, E. & MATSU'URA, S. 2006. Paleodemography of a Medieval Population in Japan: Analysis of Human Skeletal Remains from the Yuigahama-Minami Site. *American Journal of Physical Anthropology,* 131**,** 1-14.

NAKAI, M., INOUE, K. & HUKUDA, S. 2002. First Palaeopathological Example of Kienbock's Disease from Early Modern Sakhalin Ainu. *International Journal of Osteoarchaeology,* 12**,** 107-111.

NELSEN, K., N. TAYLES & DOMETT, K. 2001. Missing Lateral Incisors in Iron Age South-East Asians as Possible Indicators of Dental Agenesis. *Archives of Oral Biology,* 46**,** 963 - 971.

NELSEN, K.M. 1999. *The Dental Health of the People from Noen U-Loke.* MSc Thesis, University of Otago.

NEPUNI, W. 2010. *Socio-Cultural History of Shüpfomei Naga Tribe: A Historical Study of Ememei, Lepaona, Chüluve and Paomata Generally Known as Mao-Poumai Naga Tribe,* New Dehli, Mittal Publications.

NERI, R. & LANCELOTTI, L. 2004. Fractures of the Lower Limbs and Their Secondary Skeletal Adaptations: A 20th Century Example of Pre-Modern Healing. *International Journal of Osteoarchaeology,* 14**,** 60-66.

NESBITT, H.J. 1997. Topography, Climate and Rice Production. *In:* NESBITT, H.J. (ed.) *Rice Production in Cambodia.* Manila: International Rice Research Institute, 15-20.

NEWTON, J.S., DOMETT, K.M., O'REILLY, D.J.W. & SHEWAN, L. 2013. Dental Health in Iron Age Cambodia: Temporal Variations with Rice Agriculture. *International Journal of Paleopathology,* 3**,** 1-10.

NGUYEN, V.K. & PESCHARD, K. 2003. Inequality and Disease: A Review. *Annual Review of Anthropology,* 32**,** 447-474.

NYLAN, M. 1993. *The Canon of Supreme Mystery by Yang Hsiung: A Translation with Commentary of the T'ai Hsuan Ching by Michael Nylan*, State University of New York Press.

O'REILLY, D.J.W. 1999. *A Diachronic Analysis of Social Organisation in the Mun River Valley.* Doctor of Philosophy University of Otago.

O'REILLY, D.J.W. 2001. From the Bronze Age to the Iron Age in Thailand: Applying the Heterarchical Approach. *Asian Perspectives,* 39**,** 1-19.

O'REILLY, D.J.W. 2003. Further Evidence of Heterarchy in Bronze Age Thailand. *Current Anthropology,* 44**,** 300-306.

O'REILLY, D.J.W. 2004. Ceramic Categorisation and Description. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Ban Lum Khao.* Bangkok: The Thai Fine Arts Department, 231-237.

O'REILLY, D.J.W., CHANTHOURN, T. & DOMETT, K. 2004. A Preliminary Report on the Excavation of an Iron Age Cemetery at Phum Snay, Banteay Meanchey, Cambodia, 2003. *Udaya,* 5**,** 219-225.

O'REILLY, D.J.W., DOMETT, K. & PHENG, S. 2008. The Excavation of a Late Prehistoric Cemetery in Northwest Cambodia. *Udaya,* 7**,** 207-222.

O'REILLY, D.J.W., DRIESCH, A.V.D. & VOEUN, V. 2006. Archaeology and Archaeozoology of Phum Snay: A Late Prehistoric Cemetery in Northwestern Cambodia. *Asian Perspectives,* 45**,** 188-212.

O'REILLY, D.J.W. & SYTHA, P. 2001. Recent Excavations in Northwest Cambodia. *Antiquity,* 25**,** 265-266.

O'SHEA, J.M. 1984. *Mortuary Variability: An Archaeological Investigation,* Orlando, Florida, Academic Press.

OBERTOVA, Z. 2005. Environmental Stress in the Early Mediaeval Slavic Population at Borovce (Slovakia). *Homo,* 55**,** 283 - 291.

OESTIGAARD, T. & GOLDHAHN, J. 2006. From the Dead to the Living: Death as Transactions and Re-Negotiations. *Norwegian Archaeological Review,* 39**,** 27-48.

ORSER, C.E. 2011. *Race and Practice in Archaeological Interpretation*, University of Pennsylvania Press.

ORTNER, D.J. 2003. *Identification of Pathological Conditions in Human Skeletal Remains,* San Diego, Academic Press.

ORTNER, D.J. & MAYS, S. 1998. Dry-Bone Manifestations of Rickets in Infancy and Early Childhood. *International Journal of Osteoarchaeology,* 8**,** 45-55.

OWOC, M.A. 2005. From the Ground Up: Agency, Practice, and Community in the Southwestern British Bronze Age. *Journal of Archaeological Method and Theory,* 12**,** 257-281.

OXENHAM, M., NGUYEN, L.C. & NGUYEN, K.T. 2006. The Oral Health Consequences of the Adaption and Intensification of Agriculture in Southeast Asia. *In:* M. OXENHAM, N.T. (ed.) *Bioarchaeology of Southeast Asia.* Cambridge: Cambridge University Press, 263-289.

OXENHAM, M.F. & MATSAMURA, H. 2007. Oral and Physiological Paleohealth in Cold Adapted Peoples: Northeast Asia, Hokkaido. *American Journal of Physical Anthropology,* 135**,** 64-74.

OXENHAM, M.F., NGUYEN, L.C. & NGUYEN, K.T. 2001. Oral Health in Northern Vietnam: Neolithic through Metal Periods. *Indo Pacific Prehistoric Association Bulletin,* 22**,** 121 - 131.

PALUBECKAITE, Z., JANKAUKAS, R., ARDAGNA, Y., MACIA, Y., RIGEADE, C., SIGNOLI, M. & DUTOUR, O. 2006. Dental Status of Napoleon's Great Army's (1812) Mass Burial of Soldiers in Vilnius: Childhood Peculiarities and Adult Dietary Habits. *International Journal of Osteoarchaeology,* 16**,** 355-365.

PAPAPANOU, P.N. & TONETTI, M.S. 2000. Diagnosis and Epidemiology of Periodontal Osseous Lesions. *Periodontology 2000,* 22**,** 8-21.

PAPATHANASIOU, A. 2005. Health Status of the Neolithic Population of Alepotrypa Cave, Greece. *American Journal of Physical Anthropology,* 126**,** 377-390.

PARKER-PEARSON, M. 1999. *The Archaeology of Death and Burial,* Stroud, Sutton.

PAYNTER, R. 1989. The Archaeology of Equality and Inequality. *Annual Review of Anthropology,* 18**,** 369-399.

PEARSON, R., LEE, J., KOH, W. & UNDERHILL, A. 1989. Social Ranking in the Kingdom of Old Silla, Korea: Analysis of Burials. *Journal of Anthropological Archaeology,* 8**,** 1-50.

PECHENKINA, E.A. & DELGADO, M. 2006. Dimensions of Health and Social Structure in the Early Intermediate Period Cemetery at Villa El Salvador. *American Journal of Physical Anthropology,* 131**,** 218-235.

PEEBLES, C.S. 1971. Moundville and Surrounding Sites: Some Structural Considerations of Mortuary Practices Ii. *In:* BROWN, J.A. (ed.) *Approaches to the Social Dimensions of Mortuary Practices.* 25 ed., 68-91.

PERIZONIUS, W.R.K. 1984. Closing and Non-Closing Sutures in 256 Crania of Known Age and Sex from Amsterdam (Ad 1883 - 1909). *Journal of Human Evolution,* 13**,** 201-216.

PETTITT, P. 2011. *The Palaeolithic Origins of Human Burial,* Hoboken, Taylor & Francis.

PIETRUSEWSKY, M. & DOUGLAS, M.T. 2002a. Appendix E, Databases E1-E12, (Web Ver 1.1 at Http://Seasia.Museum.Upenn.Edu/Skeletal/), Ban Chiang, a Prehistoric Village Site in Northeast Thailand I: The Human Skeletal Remains by Michael Pietrusewsky and Michele Toomay Douglas. Thai Archaeology Monograph Series Volume 1. University of Pennsylvania Museum of Anthropology and Archaeology.

PIETRUSEWSKY, M. & DOUGLAS, M.T. 2002b. *Ban Chiang, a Prehistoric Village Site in Northeast Thailand: The Human Skeletal Remains,* Philadelphia, University of Pennsylvania.

PIETRUSEWSKY, M. & DOUGLAS, M.T. 2002. Intensification of Agriculture at Ban Chiang: Is There Evidence from the Skeletons? *Asian Perspectives,* 40**,** 157-178.

PIGOTT, V.C., MUDAR, K.M., AGELARAKIS, A., KEALHOFER, L., WEBER, S.A. & VOELKER, J.C. 2007. A Program of Analysis of Organic Remains from Prehistoric Copper-Producing Settlements in the Khao Wong Prachan Valley, Central Thailand: A Progress Report. *In:* BACUS, E., GLOVER, I.C. & PIGOTT, V.C. (eds.) *Uncovering Southeast Asia's Past.* Singapore: NUS Press, 154-167.

PIGOTT, V.C., WEISS, A.D. & NATAPINTU, S. 1997. The Archaeology of Copper Production: Excavations in the Khao Wong Prachan Valley, Central Thailand. . *In:* CIARLA, R. & RISPOLI, F. (eds.) *South-East Asian Archaeology 1992.* Rome: Istituto Italiano per l'Africa e l'Oriente, 119-157.

PINHASI, R. & STOCK, J.T. (eds.) 2011. *Human Bioarchaeology of the Transition to Agriculture,* Chichester: Wiley-Blackwell.

PINHEIRO, J., CUNHA, E., CORDEIRO, C. & NUNO VIERA, D. 2004. Bridging the Gap between Forensic Anthropology and Osteoarchaeology - a Case of Vascular Pathology. *International Journal of Osteoarchaeology,* 14**,** 137-144.

POLLEX, A. 1999. Comments on the Interpretation of the So-Called Cattle Burials of Neolithic Central Europe. *Antiquity,* 73**,** 542-550.

PORČIĆ, M. & STEFANOVIĆ, S. 2009. Physical Activity and Social Status in Early Bronze Age Society: The Mokrin Necropolis. *Journal of Anthropological Archaeology,* 28**,** 259-273.

POWELL, M. 1986. *Late Prehistoric Community Health in the Central Deep South: Biological and Social Dimensions of the Mississippian Chiefdom at Moundville, Alabama,* Raleigh, North Carolina Archaeological Council : Archaeology Branch, Archaeology and Historic Preservation Section, North Carolina Division of Archives and History.

POWELL, M.L. 1992. In the Best of Health? Disease and Trauma among the Mississippian Elite. *Archeological Papers of the American Anthropological Association,* 3**,** 81-97.

PRADER, A., TANNER, J.M. & VON HARNACK, G.A. 1963. Catch-up Growth Following Illness or Starvation: An Example of Developmental Canalization in Man. *The Journal of Pediatrics,* 62**,** 646-659.

PRICE, T.D. & BROWN, J.A. 1985. *Prehistoric Hunter-Gatherers : The Emergence of Cultural Complexity,* Orlando, Academic Press.

RAJENDRAN, R. 2009. Developmental Disturbances of Oral and Peraoral Structures. *In:* SIVAPATHASUNDHARAM, S. & RAJENDRAN, R. (eds.) *Shafer's Textbook of Oral Pathology.* Sixth ed. Noida, India: Elsevier.

REDMAN, C.L. 1978. *The Rise of Civilization : From Early Farmers to Urban Society in the Ancient near East,* San Francisco, W. H. Freeman.

REHDER, J.E. 2000. *The Mastery and Uses of Fire in Antiquity,* London, McGill-Queen's University Press.

REITZ, E.J. & WING, E.S. 1999. *Zooarchaeology,* Cambridge, Cambridge University Press.

RENFREW, C. & BAHN, P. 2008. *Archaeology: Theories, Method and Practice,* London, Thames and Hudson.

REYNOLDS, A. 2009. *Anglo-Saxon Deviant Burial Customs,* OUP Oxford.

REYNOLDS, J. 1962. An Evaluation of Some Roentgenographic Signs in Sickle Cell Anemia and Its Variants. *Southern Medical Journal,* 55**,** 1123-1128.

ROBB, J., BIGAZZI, R., LAZZARINI, L., SCARSINI, C. & SONEGO, F. 2001. Social "Status" and Biological "Status": A Comparison of Grave Goods and Skeletal Indicators from Pontecagnano. *American Journal of Physical Anthropology,* 115**,** 213-222.

ROBBINS, S.L., COTRAN, R.S. & KUMAR, V. 1984. *Pathological Basis of Disease,* Philidelphia, Igaku-Shoin/Saunders.

ROTHSCHILD, B.M. 1997. Porosity: A Curiosity without Diagnostic Significance. *American Journal of Physical Anthropology,* 104**,** 529-533.

ROUSSEAU, J. 2006. *Rethinking Social Evolution,* Montreal, McGill-Queens Press

ROUTLEDGE, W.S. & ROUTLEDGE, K. 1968. *With a Prehistoric People: A Kikuyu of British East Africa,* London, Frank Cass and Co.

RUFF, C.B. 2000. Biomechanical Analysis of Archaeological Human Skeletons. *In:* KATZENBERG, M.A. & SAUNDERS, S.R. (eds.) *Biological Anthropology of the Human Skeleton.* New York: J. Wiley & Sons, 71-102.

RUPP, D.W. 1989. Ruttin' on the Ritz: Manifestations of High Status in Iron Age Cyprus. *In:* PELTENBERG, E. (ed.) *Early Society in Cyprus.* Edinburgh: Edinburgh University Press, 336-362.

RUSSELL, N. 2011. *Social Zooarchaeology: Humans and Animals in Prehistory,* New York, Cambridge University Press.

SARGEANT, C. 2010. A Characterization of Mortuary Ceramics from Ban Non Wat, Northeast Thailand. *Bulletin of the Indo-Pacific Prehistory Association,* 20**,** 163-177.

SASSOON, R. & GAUR, A. 1997. *Signs Symbols and Icons: Pre-History to the Computer Age,* Exeter, Intellect Books.

SAXE, A.A. 1971. Social Dimensions of Mortuary Practices in a Mesolithic Population from Wadi Halfa, Sudan. *In:* BROWN, J.A. (ed.) *Approaches to the Social Dimensions of Mortuary Practices.* 25 ed., 39-57.

SAYAVONGKHAMDY, T., BELLWOOD, P. & BULBECK, D. 2000. Recent Archaeological Research in Laos. *Indo Pacific Prehistoric Association Bulletin,* 19**,** 101-110.

SCARBOROUGH, V.L., VALDEZ, J.F. & DUNNING, N.P. 2003. *Heterarchy, Political Economy, and the Ancient Maya: The Three Rivers Region of the East-Central Yucatàn Peninsula,* University of Arizona Press.

SCHEID, R.C. & WEISS, G. 2011. *Dental Anatomy,* Philadelphia, Lippincott Williams & Wilkins.

SCHEPARTZ, L.A., MILLER-ANTONIO, S. & MURPHY, J.M.A. 2009. *Differential Health among the Myceneans of Messenia: Status, Sex, and Dental Health at Pylos,* Athens, American School of Classical Studies at Athens.

SCHEUER, L. & BLACK, S. 2000. Development and Aging of the Juvenile Skeleton. *In:* COX, M. & MAYS, S. (eds.) *Human Osteology in Archaeology and Forensic Science.* London: Greenwich Medical Media, 9-21.

SCHEUER, L., SCHAEFER, M. & BLACK, S. 2008. *Juvenile Osteology: A Laboratory and Field Manual,* Burlington MA, Academic Press.

SCHMITT, A. 2004. Age at Death Assessment Using the Os Pubis and the Auricular Surface of the Ilium: A Test on an Identified Asian Sample. *International Journal of Osteoarchaeology,* 14**,** 1-6.

SCHMITT, A. & MURAIL, P. 2003. Is the First Rib a Reliable Indicator of Age at Death Assessment? Test of the Method Developed by Kunos Et Al (1999). *Homo,* 54**,** 207-214.

SCHWEICH, M. & KNUSEL, C. 2003. Bio-Cultural Effects in Medieval Populations. *Economics and Human Biology,* 1**,** 367 - 377.

SCIULLI, P.W. 1997. Dental Evolution in Prehistoric Native Americans of the Ohio Valley Area. I. Wear and Pathology. *International Journal of Osteoarchaeology,* 7**,** 507-524.

SERVICE, E.R. 1962. *Primitive Social Organization : An Evolutionary Perspective,* New York, Random House.

SHANKS, M. & TILLEY, C. 1982. Ideology, Symbolic Power and Ritual Communication: A Reinterpretation of Neolithic Mortuary Practices. *In:* HODDER, I. (ed.) *Symbolic and Structural Archaeology.* Cambridge: Cambridge University Press, 129-154

SHAWE, D.R. 1984. Geology and Mineral Deposits of Thailand. Denver: US Department of the Interior and US Geological Survey.

SHIMADA, I., SHINODA, K., FARNUM, J., CORRUCCINI, R. & WATANABE, H. 2004. An Integrated Analysis of Pre-Hispanic Mortuary Practices: A Middle Sican Case Study. *Current Anthropology,* 45**,** 369-402.

SHOICHET, R.M. 2006. *Osteoarthritis at Phum Snay (Iron Age, Northwest Cambodia), a Comparative Study.* BA (Hons), James Cook University.

SIMANA, S. & PREISIG, W. 2006. Rice-Based Traditions and Rituals of the Kmhmu'. *In:* SCHILLER, J.M. (ed.) *Rice in Laos.* Los Baños, Philippines: IRRI, 79-106.

SIVAPATHASUNDHARAM, S. 2009. Diseases of the Periodontium. *In:* SIVAPATHASUNDHARAM, S. & RAJENDRAN, R. (eds.) *Shafer's Textbook of Oral Pathology.* 6 ed. Noida, India: Elsevier.

SMITH, B.H. 1984. Patterns of Molar Wear in Hunter-Gatherers and Agriculturalists. *American Journal of Physical Anthropology,* 63**,** 39-56.

SOLOMON, S., GREENBERG, J., SCHIMEL, J., ARNDT, J. & PYSZCZYNKI, T. 2008. Human Awareness of Mortality and the Evolution of Culture. *In:* SCHALLER, M. & CRANDALL, C.S. (eds.) *The Psychological Foundations of Culture.* New Jersey: Lawrence Erlbaum Associates Inc., 15-40.

SØRENSEN, M.L.S. 2000. *Gender Archaeology,* Cambridge, Polity Press.

SORENSEN, P. 1973. Prehistoric Iron Implements from Thailand. *Asian Perspectives,* 16**,** 134-173.

SPECTOR, T.D., CICUTTINI, F., BAKER, J., LOUGHLIN, J. & HART, D. 1996. Genetic Influences on Osteoarthritis in Women: A Twin Study. *British Medical Journal,* 7036**,** 940-944.

SPRIGGS, M. (ed.) 1984. *Marxist Perspectives in Archeology*: Cambridge University Press.

SRICHAMPA, S. 2014. Thai Amulets: Symbol of the Practice of Multi-Faiths and Cultures. *In:* LIAMPUTTONG, P. (ed.) *Contemporary Socio-Cultural and Political Perspectives in Thailand.* London: Springer, 49-64.

STARK, M.T. 2004. Pre-Angkorian and Angkorian Cambodia. *In:* I. GLOVER, P.B. (ed.) *Southeast Asia: From Prehistory to History.* London: Routledge Curzon, 89-119.

STARK, M.T. & SOVATH, B. 2001. Recent Research on Emergent Complexity in Cambodia's Mekong. *Indo Pacific Prehistoric Association Bulletin,* 21**,** 85 - 98.

STECH-WHEELER, T. & MADDIN, R. 1976. The Techniques of the Early Thai Metalsmith. *Expedition,* 18**,** 38-47.

STECKEL, R.H. 2002. A Global History of Health: The Evolution of a Research Agenda. *Physical Anthropology: Official Newsletter of the American Association of Physical Anthropologists*, p.3.

STECKEL, R.H. 2005. Health and Nutrition in Pre-Columbian America: The Skeletal Evidence. *Journal of Interdisciplinary History,* 36**,** 1-32.

STECKEL, R.H. & ROSE, J.C. (eds.) 2002. *The Backbone of History, Health and Nutrition in the Western Hemisphere,* Cambridge: Cambridge University Press.

STECKEL, R.H., ROSE, J.C., LARSEN, C.S. & WALKER, P.L. 2002a. Skeletal Health in the Western Hemisphere from 4000 B.C. To the Present. *Evolutionary Anthropology,* 11**,** 142-155.

STECKEL, R.H., SCIULLI, P.W. & ROSE, J.C. 2002b. A Health Index from Skeletal Remains. *In:* STECKEL, R.H. & ROSE, J.C. (eds.) *The Backbone of History: Health and Nutrition in the Western Hemisphere.* New York: Cambridge University Press,

STETS, J.E. & BURKE, P.J. 2000. Identity Theory and Social Identity Theory. *Social Psychology Quarterly,* 63**,** 224-237.

STINI, W.A. 1985. Growth Rates and Sexual Dimorphism in Evolutionary Perspective. *In:* R.I. GILBERT, J.H.M. (ed.) *The Analysis of Prehistoric Diets.* Orlando: Academic Press, 191-226.

STINSON, S. 1985. Sex Differences in Environmental Sensitivity During Growth and Development. *Yearbook of Physical Anthropology,* 28**,** 123-147.

STONE, R. 2006. Local Elites Cast New Light on Angkor’s Rise. *Science.*

STRAUS, L.G., MORALES, M.R.G. & CARRETERO, J.M. 2011. Lower Magdalenian Secondary Human Burial in El Mirón Cave, Cantabria, Spain. *Antiquity,* 85**,** 1151-1164.

STUART-MACADAM, P. 1985. Porotic Hyperstosis: Representative of a Childhool Condition. *American Journal of Physical Anthropology,* 66**,** 391 - 198.

STUART-MACADAM, P. 1998. Iron Deficiency Anemia: Exploring the Difference. *In:* GRAUER, A.L. & STUART-MACADAM, P. (eds.) *Sex and Gender in Paleopathological Perspective.* Cambridge University Press, 45-63.

SUCHEY, J.M. & KATZ, D. 1986. Skeletal Age Standards Derived from an Extensive Multiracial Sample of Modern Americans - Abstract. *American Journal of Physical Anthropology,* 69**,** 269.

SUCKLING, G.W. 1989. Developmental Defects of Enamel - Historical and Present-Day Perspectives of Their Pathogenesis. *Advances in Dental Research,* 3**,** 87-94.

SWANSON, G.E. 1971. An Organizational Analysis of Collectivities. *American Sociological Review,* 36**,** 607-624.

TAINTER, J.R. 1978. Mortuary Practices and the Study of Prehistoric Social Systems. *In:* SCHIFFER, M. (ed.) *Advances in Archaeological Method and Theory.* New York: Academic Press, 105 -141.

TALBOT, S. 2007. The Analysis of the Mortuary Record. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 304-352.

TANNER, J.M. 1981. Catch-up Growth in Man. *British Medical Bulletin,* 37**,** 233-238.

TANNER, J.M. 1989. *Foetus into Man: Physical Growth from Conception to Maturity,* Cambridge, Harvard University Press.

TAYLES, N. 1996. Anaemia, Genetic Diseases and Malaria in Prehistoric Mainland South East Asia. *American Journal of Physical Anthropology,* 101**,** 11-27.

TAYLES, N. 1999. *The Excavation of Khok Phanom Di: A Prehistoric Site in Central Thailand. The People.,* London, The Society of Antiquaries of London.

TAYLES, N. 2003. Murder or Mortuary Behaviour? An Iron Age Enigma from Northeast Thailand. *International Journal of Osteoarchaeology,* 13**,** 197-206.

TAYLES, N. & BUCKLEY, H.R. 2004. Leprosy and Tuberculoses in Iron Age South East Asia? *American Journal of Physical Anthropology,* 125**,** 239-256.

TAYLES, N., DOMETT, K. & HALCROW, S. 2009. Can Dental Caries Be Interpreted as Evidence of Farming? The Asian Experience. *In:* KOPPE, T., MEYER, G. & ALT, K.W. (eds.) *Comparative Dental Morphology.* Basel: Karger,

TAYLES, N., DOMETT, K. & NELSEN, K. 2000. Agriculture and Dental Caries? The Case of Rice in Prehistoric Southeast Asia. *World Archaeology,* 32**,** 68-83.

TAYLES, N., HALCROW, S. & DOMETT, K. 2007. The People of Noen U-Loke. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 243-286.

TAYLES, N.G., DOMETT, K. & HUNT, V. 1998. The People of Nong Nor. *In:* HIGHAM, C.F.W. & THOSARAT, R. (eds.) *The Excavation of Nong Nor.* Dunedin: University of Otago,

THAILAND DEPARTMENT OF MINERAL RESOURCES. 2002. *Map - Copper Deposits, Thailand.* Bangkok: Thailand Department of Mineral Resources.

THEUNISSEN, R. 2007. The Agate and Carnelian Ornaments. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 359-378.

THEUNISSEN, R., GRAVE, P. & BAILEY, G. 2000. Doubts on Diffusion: Challenging the Assumed Indian Origin of Iron Age Agate and Carnelian Beads in Southeast Asia. *World Archaeology,* 32**,** 84-105.

THOMAS, J. 2004. *Archaeology and Modernity*, London, Routledge.

TRIGGER, B.G. 1980. *Gordon Childe: Revolutions in Archaeology,* London, Thames and London.

TRIGGER, B.G. 1989. *A History of Archaeological Thought,* Cambridge, Cambridge University Press.

TRIGGER, B.G. 1998. *Sociocultural Evolution: Calculation and Contingency,* Oxford, Blackwell.

TURKON, P. 2004. Food and Status in the Prehispanic Malpaso Valley, Zacatecas, Mexico. *Journal of Anthropological Archaeology,* 23**,** 225-251.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES 1991. *Healthy People 2000 : National Health Promotion and Disease Prevention Objectives,* Conference ed., U.S. Department of Health and Human Services, Public Health Service.

UBELAKER, D. 2000. Temporal Trends in Old World Patterns of Morbidity. *Chungara,* 32**,** 33-40.

UBELAKER, D.H. & PAP, I. 1998. Skeletal Evidence for Health and Disease in the Iron Age of Northeastern Hungary. *International Journal of Osteoarchaeology,* 8**,** 231-251.

UCKO, P.J. 1969. Ethnography and Archaeological Interpretation of Funerary Remains. *World Archaeology,* 1**,** 262-280.

US GEOLOGICAL SURVEY. n.d.-a. *Cambodia - Map of Mineral Deposits*. US Geological Survey.

US GEOLOGICAL SURVEY. n.d.-b. *Thailand - Map of Mineral Deposits*. US Geological Survey.

VAN DEN EELAART, A.L. 1976. Map - Climatic Regions of Thailand 1:4,000,000. *Atlas of Thailand* [Online]. Available: http://eusoils.jrc.ec.europa.eu/Esdb_Archive/EuDASM/Asia/maps/TH2000_1CL.htm.

VAN SAASE, J.L., VAN ROMUNDE, L.K., CATS, A., VANDENBROUCKE, J.P. & VALKENBURG, H.A. 1989. Epidemiology of Osteoarthritis: Zoetermeer Survey. Comparison of Radiological Osteoarthritis in a Dutch Population with That in 10 Other Populations. *Annals of the Rheumatic Diseases,* 48**,** 271-280.

VARNEY, P. 2012. The Modernization of Iban Eschatology: Iban Burial Ritual and Afterlife Beliefs in Contemporary Kuching. *Borneo Research Bulletin,* 43**,** 134.

VERMEULE, E. 1979. *Aspects of Death in Early Greek Art and Poetry,* University of California Press.

VINCENT, B. 2006. Crossing the Style Barrier: New Evidence from Thailand. *In:* BACUS, E.A., GORMAN, I.C. & PIGOTT, V.C. (eds.) *Uncovering Southeast Asia's Past.* Singapore: NUS Press, 137-147.

VOELKER, J. 2007. The Ceramics. *In:* HIGHAM, C., KIJNGAM, A. & TALBOT, S. (eds.) *The Excavation of Noen U-Loke and Non Muang Kao.* Bangkok: The Thai Fine Arts Department, 487-494.

WALDRON, T. 1994. *Counting the Dead: The Epidemiology of Skeletal Populations,* Chichester, John Wiley.

WALDRON, T. 2009. *Paleopathology,* Cambridge, Cambridge University Press.

WALKER, P.L. 2001. A Bioarchaeological Perspective on the History of Violence. *Annual Review of Anthropology,* 30**,** 573-596.

WALKER, P.L., DEAN, G. & SHAPIRO, P. 1991. Estimating Age from Tooth Wear in Archaeological Populations. *In:* KELLEY, M. & LARSEN, C.S. (eds.) *Advances in Dental Anthropology.* New York: Alan R. Liss, 169-178.

WALKER, P.L., DRAYER, F.J. & SIEFKIN, S.K. 1996. Malibu Human Skeletal Remains: A Bioarchaeological Analysis. Sacramento: Resource Management Divisions, Department of Parks and Recreation.

WALKER, P.L. & HEWLETT, B.S. 1990. Dental Health Diet and Social Status among Central African Foragers and Farmers. *American Anthropologist,* 92**,** 383-398.

WALKER-BONE, K. & PALMER, K.T. 2002. Musculoskeletal Disorders in Farmers and Farm Workers. *Occupational Medicine,* 52**,** 441-450.

WAPLER, U., CRUBEZY, E. & SCHULTZ, M. 2004. Is Cribra Orbitalia Synonymous with Anaemia? Analysis and Interpretation of Cranial Pathology in Sudan. *American Journal of Physical Anthropology,* 123**,** 333-339.

WASON, P.K. 1994. *The Archaeology of Rank,* Cambridge University Press.

WEBB, S. 1995. *Palaeopathology of Aboriginal Australians,* Cambridge, Cambridge University Press.

WEINBERG, E.D. 1992. Iron Withholding in Prevention of Disease. *In:* STUART-MACADAM, P. & KENT, S. (eds.) *Diet, Demography, and Disease: Changingperspectives on Anemia.* New York: Aldine de Gruyter, 105-150.

WEISS, E. 2006. Osteoarthritis and Body Mass. *Journal of Archaeological Science,* 33**,** 690-695.

WEISS, E. & JURMAIN, R. 2007. Osteoarthritis Revisited: A Contemporary Review of Aetiology. *International Journal of Osteoarchaeology,* 17**,** 437-450.

WEISS, K.M. 1973. *Demographic Models for Anthropology,* Washington, Society for American Archaeology.

WELCH, D. & SCARRY, C.M. 1995. Status-Related Variation in Foodways in the Moundville Chiefdom. *American Antiquity,* 60**,** 397-419.

WENTZ, R.K. 2006. *A Bioarchaeological Assessment of Health from Florida's Archaic: Application of the Western Hemisphere Health Index to the Remains from Windover (8br246).* Doctor of Philosophy, Florida State University.

WESOLOWSKI, V. 2006. Caries Prevalence in Skeletal Series - Is It Possible to Compare? *Memoirs Instituto Oswaldo Cruz,* 101**,** 139-145.

WHITE, J. & PIGOTT, V. 1996. From Community Craft to Regional Specialization. *In:* CHILDE, V.G. & WAILES, B. (eds.) *Craft Specialization and Social Evolution: In Memory of V. Gordon Childe.* University of Pennsylvania Museum of Archaeology and Anthroplogy, 152-175.

WHITE, J.C. 1982. *Ban Chiang: Discovery of a Lost Bronze Age,* Philadelphia, University of Pennsylvania Press.

WHITE, J.C. 1995. Heterarchy into Theory on Socio-Political Development: The Case from Southeast Asia. *In:* EHRENREICH, R., CRUMSLEY, C. & LEVY, J. (eds.) *Heterarchy and the Analysis of Complex Societies.* Washington DC: American Anthropological Association, 101-123.

WHITE, J.C., PENNY, D., KEALHOFER, L. & MALONEY, B. 2004. Vegetation Changes from the Late Pleistocene Thought the Holocene from Three Areas of Archaeological Significance in Thailand. *Quaternary International,* 113**,** 111-132.

WHITE, T.D. & FOLKENS, P.A. 2000. *Human Osteology,* San Diego, Academic Press.

WHO 2006. Constitution of the World Health Organization. *Basic Documents: Supplements.* Geneva: World Health Organization, 1-18.

WHO. 2007. *International Classification of Diseases* [Online]. World Health Organization. Available: www.who.int/classifications/icd/en/index.html [Accessed February 2011].

WILKINSON, R.G. 1996. *Unhealthy Societies: The Afflictions of Inequality,* New York, Routledge.

WILKINSON, R.G. & NORELLI, R.J. 1981. A Biocultural Analysis of Social Organization at Monte Alban. *American Antiquity,* 46**,** 743-758.

WILLIS, A. 2003. *Social Status and Biological Status: Is There a Relationship at Ban Lum Khao.* Hons (BA), University of Otago.

WOO, E.J. & SCIULLI, P.W. 2013. Degenerative Joint Disease and Social Status in the Terminal Late Archaic Period (1000-500b.C.) of Ohio. *International Journal of Osteoarchaeology,* 23**,** 529-544.

WOOD, J.W., MILNER, G.R., HARPENDING, H.C. & WEISS, K.M. 1992. The Osteological Paradox. *Current Anthropology,* 33**,** 343-370.

WRESCHNER, E.E. 1980. Red Ochre and Human Evolution: A Case for Discussion [and Comments and Reply]. *Current Anthropology,* 21**,** 631-644.

WRIGHT, L.E. 1997. Intertooth Patterns of Hypoplasia Expression: Implications for Childhood Health in the Classic Maya Collapse. *American Journal of Physical Anthropology,* 102**,** 233-247.

WRIGHT, L.E. & YODER, C.J. 2003. Recent Progress in Bioarchaeology: Approaches to the Osteological Paradox. *Journal of Archaeological Research,* 11**,** 43-70.

WRIGLEY, E.A. 1988. *Continuity, Chance and Change : The Character of the Industrial Revolution in England,* Cambridge, Cambridge University Press.

WU, J.C. 2008a. The Mineral Industry of Cambodia. *In:* US GEOLOGICAL SURVEY (ed.) *2007 Minerals Yearbook.* 8.1 **-** 8.5.

WU, J.C. 2008b. The Mineral Industry of Laos. *In:* US GEOLOGICAL SURVEY (ed.) *2007 Minerals Yearbook.* 16.1-16.5.

ZHOU, L. & CORRUCCINI, R.S. 1998. Enamel Hypoplasias Related to Famine Stress in Living Chinese. *American Journal of Human Biology,* 10**,** 723-733.

ZVELEBIL, M. & WEBER, A.W. 2013. Human Bioarchaeology: Group Identity and Individual Life Histories – Introduction. *Journal of Anthropological Archaeology,* 32**,** 275-279.

12 APPENDICES

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Appendix A Health Data

Table A 1: Level of wear noted in individuals from the Ban Non Wat sample.

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
155	Mid Bronze	Male	Mid adult	30	Severe	Most of the mandibular teeth have some degree of wear. Dentine exposure is visible in molars, canines and incisors, but fissures are still visible in premolars. All of the maxillary teeth have exposed dentine. A first incisor shows labial wear.	
159	Mid Bronze	Male	Mid adult	0	-	No dentition.	
210	Mid Bronze	Male	Old adult	12	Severe	An older individual, most of the teeth have been lost ante-mortem. Surviving teeth are very worn. Right maxillary molar has a concave shape.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
392	Mid Bronze	Male	Adult	28	Moderate	Maxillary dentition has a higher degree of attrition than the mandibular dentition. Fissures are still evident in the mandibular dentition.	
407	Mid Bronze	Female	Old adult	18	Severe	All teeth show deep wear, the right maxillary premolars appear to have been worn down to the CEJ.	
408	Mid Bronze	Male	Old adult	25	Severe	Most of the teeth have worn below the CEJ.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
416	Mid Bronze	Female	Young adult	14	Moderate	Most teeth are loose and broken. Fissures are still evident in the mandibular dentition.	
431	Mid Bronze	Male	Old adult	31	Severe	All of the teeth are worn. Many of the mandibular molars and premolars have buccal wear.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
449	Mid Bronze	Female	Young adult	27	Moderate to severe	The mandibular molars have severe attrition, where the dentine has been exposed. The remaining teeth have light to moderate levels of wear.	
535	Mid Bronze	Female	Mid adult	6	Moderate to severe	The molars have the most severe wear, although some evidence of fissures in some.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
539	Mid Bronze	Male	Mid adult	31	Moderate	The maxillary molars facets are flattish, whilst the mandibular molars have dentine exposure or non-carious pits.	
549	Mid Bronze	Male	Mid adult	23	Moderate to severe	The molars and incisors are well worn, yet the premolars are not. The enamel on the premolars is intact.	
554	Mid Bronze	Female	Mid adult	28	Moderate	The central left maxillary incisor is worn into a conical shape. The opposing mandible incisor appears to have worn it down. The maxillary left first molar also has unusual wear but there appears to be little occlusion. Dentine is exposed in many teeth.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
123	Late Bronze	Male	Mid adult	25	Moderate to severe	Many teeth have dentine exposure, whilst others have fissures and moderate attrition.	
126	Late Bronze	Unknown	Adult	19	Moderate	Some of the dentine in the incisors are exposed, but most of the dentition is only moderately worn, with fissures evident in molars and premolars.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
129	Late Bronze	Female	Young – Mid adult	10	Severe	Dentine is evident in the molars, although wear is only partially affecting the third molar on the right side.	
185	Late Bronze	Male	Mid adult	28	Moderate to severe	All of the teeth have wear, with severe attrition on the maxillary premolars.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
186	Late Bronze	Male	Old adult	22	Severe	The majority of the anterior maxillary teeth are worn close to the CEJ. The mandibular dentition are also well worn.	
215	Late Bronze	Female	Adult	23	Moderate to severe	Many teeth have been worn close to the CEJ.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
218	Late Bronze	Female	Mid adult	28	Moderate to severe	The maxillary teeth appear more worn than the mandibular teeth. The dentine has been exposed in most teeth.	
227	Late Bronze	Female	Old adult	21	Severe	All of the teeth are well worn, with dentine exposure.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
265	Late Bronze	Male	Mid adult	25	Light	This individual has some wear, but it is considered to be light, as most teeth have marked fissures, although most cusps in molars have been worn away.	
229	Early Iron	Unknown	Adult	28	Light	The anterior incisors have some wear but the majority of teeth have intact enamel and cusps.	
231	Early Iron	Male	Mid adult	29	Moderate	Most teeth have dentine exposure.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
237	Early Iron	Female	Adult	20	Moderate to severe	There are varying degrees in attrition in the dentition. All teeth have been worn down to dentine.	
319	Early Iron	Female	Old adult	18	Moderate to severe	Most teeth have been worn to dentine, some with angles that almost impact on the CEJ. The third molar has not been affected.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
323	Early Iron	Female	Old adult	11	Severe	The mandibular incisors are highly worn and have an unusual uneven wear pattern.	
325	Early Iron	Male	Young adult?	24	Moderate to severe	Most of the teeth have moderate attrition. Molars have fissures, but maxillary teeth have increases level of attrition.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
334	Early Iron	Female	Young adult	24	Moderate	Maxillary dentition has irregular wear patterns. The premolars, canines and incisors are alternatively higher and lower. Mandibular teeth do not occluse well with maxillary teeth especially on the left side. The lateral left maxillary incisor is unusually shaped with a pocket. The right lateral incisor is similar.	
360	Early Iron	Unknown	Mid adult	10	Moderate to severe	Most teeth have dentine exposure.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
367	Early Iron	Male	Young adult	13	Severe	Dentine exposure is evident in the teeth.	
382	Early Iron	Unknown	Adult	7	-	Teeth are loose and mainly incomplete.	No photo
383	Early Iron	Female	Adult	29	Severe	Mandibular dentition has uneven attrition pattern. Maxillary anterior teeth have a severe degree of attrition compared to the premolars and molars,	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
390	Early Iron	Male	Adult	22	Moderate to severe	The maxillary dentition has higher degree of attrition than the mandibular dentition. The second maxillary molar is not worn.	
415	Early Iron	Unknown	Young adult	29	Light	Whilst some wear is evident, the enamel is intact in most teeth.	

BURIAL	PHASE	SEX	AGE	NO OF TEETH WITH VISIBLE OCCLUSAL SURFACE.	WEAR NOTED ON ALL SURFACES	COMMENTS	PHOTO
419	Early Iron	Female	Young adult	1	Light	The enamel is intact in most teeth.	
433	Early Iron	Female	Mid adult	31	Light to moderate	The majority of teeth have intact enamel, although some of the anterior teeth have some dentine exposure.	
474	Early Iron	Female	Young adult	28	Light	Wear is light as most of the enamel is intact.	

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Table A 2: : Individuals with evidence of periodontal disease at Ban Non Wat.

BURIAL	SEX	AGE	PHASE	PERIODONTAL DISEASE – HORIZONTAL BONE LOSS % TOOTH POSITIONS AFFECTED	INFRABONY POCKET NO. TEETH AFFECTED	
155	Male	Mid adult	Mid Bronze	13	0	
210	Male	Older adult	Mid Bronze	10	0	
215	Female	Mid adult	Late Bronze	4.3	0	
227	Female	Older adult	Late Bronze	0	1	
237	Female	Mid adult	Early Iron	4.8	0	-
319	Female	Older adult	Early Iron	63.2	1	
334	Female	Young adult	Early Iron	6.3	0	

BURIAL	SEX	AGE	PHASE	PERIODONTAL DISEASE – HORIZONTAL BONE LOSS % TOOTH POSITIONS AFFECTED	INFRABONY POCKET NO. TEETH AFFECTED	
390	Male	Mid adult	Early Iron	12	0	
408	Male	Older adult	Mid Bronze	16.7	0	
431	Male	Older adult	Mid Bronze	0	2	-
535	Female	Mid adult	Mid Bronze	0	1	
549	Male	Mid adult	Mid Bronze	6.7	0	

Table A 3: Individuals afflicted by periodontal disease compared with the Phase at Ban Non Wat.

PHASE	NUMBER OF INDIVIDUALS AFFECTED	% OF PHASE SAMPLE AFFECTED
Mid Bronze	6	46.2
Late Bronze	2	22.2
Early Iron	4	25.0

Table A 4: List of individuals showing evidence of periapical cavities at Ban Non Wat.

BURIAL	SEX	AGE	PHASE	NO. OF PERIAPICAL CAVITIES	PHOTO
186	Unknown	Young adult	Late Bronze	2	
237	Female	Mid adult	Early Iron	1	
407	Unknown	Mid adult	Mid Bronze	2	
408	Unknown	Young adult	Mid Bronze	1	
474	Male	Mid adult	Early Iron	1	
549	Female	Young adult	Mid Bronze	1	

Table A 5: Comparison of prevalence of caries in Noen U-Loke, taken from Tayles et al. (2007), and Ban Non Wat sample.

	BY INDIVIDUAL			BY TOOTH POSITIONS		
	All adults Affected/No of indiv. (%)	*Females* Affected/N. of indiv (%)	*Males* Affected/No of indiv (%)	*All adults* Affected/No of teeth (%)	*Females* Affected/No of teeth (%)	*Males* Affected/No of teeth (%)
Noen U-Loke All adults	23/54 (42.3)	10/20 (50.0)	10/23 (43.5)	46/956 (4.8)	22/382 (5.8)	19/422 (4.5)
Ban Non Wat All adults	18/38 (47%)	10/17 (59%)	6/16 (38%)	41/873 (4.7)	20/362 (5.5)	18/390 (4.6)
Noen U-Loke Young adults	13/28 (46.4)	4/7 (57.1)	7/15 (46.7)	20/581 (3.4)	5/153 (3.3)	12/308 (3.9)
Ban Non Wat Young adults	4/9 (44.4)	4/6 (67)	0/2 (0)	11/190 (5.8)	11/123 (8.9)	0/37 (0)
Noen U-Loke Mid to Older adults	10/25 (40.0)	6/13 (46.1)	3/8 (37.5)	26/373 (7.0)	17/229 (7.4)	7/114 (6.1)
Ban Non Wat Mid to Older adults	14/29 (48)	6/11 (55)	7/14 (50)	30/683 (4.4)	9/239 (3.8)	18/353 (5.1)
Ban Non Wat Mid adults	8/21 (38)	3/7 (43)	4/10 (40)	18/513 (3.5)	5/167 (3)	10/255 (3.9)
Ban Non Wat Older adults	6/8 (75)	3/4 (75)	3/4 (75)	12/170 (7.1)	4/72 (5.6)	8/98 (8.2)

Table A 6: Number of tooth positions and Individuals from Noen U-Loke with missing lateral incisors (taken from Nelsen et al., 2001).

	MAXILLA	MANDIBLE	TOTAL
Right	14/32 (44%)	13/34 (38%)	27/66 (41%)
Left	15/34 (44%)	18/32 (56%)	33/66 (50%)
Total teeth missing	29/66 (44%)	31/66 (47%)	60/132 (45%)
Total individuals affected	30/38 (79%)		

Table A 7: Comparison of AMTL between Ban Non Wat and Noen U-Loke. Noen U-Loke data taken from Tayles (2007).

	BY INDIVIDUAL			BY TOOTH POSITIONS		
	All adults Affected/ No. of indiv. (%)	*Females* Affected/ No. of indiv (%)	*Males* Affected/ No. of indiv (%)	*All adults* Affected/ No. of tooth positions (%)	*Females* Affected/ No. of tooth positions (%)	*Males* Affected/ No. of tooth positions (%)
Noen U-Loke All adults	22/54 (40.7)	11/20 (55.0)	9/23 (39.1)	69/1334 (5.2)	46/557 (8.3)	16/569 (2.8)
Ban Non Wat All adults	21/38 (55.3)	9/17 (53%)	9/16 (50%)	68/941 (7.2)	33/395 (8.4)	32/422 (7.6)
Noen U-Loke Young adults	5/28 (17.9)	1/7 (14.3)	3/15 (20.0)	7/696 (1.0)	3/197 (1.5)	3/363 (0.8)
Ban Non Wat Young adults	4/9 (44.4)	1/6 (16.7)	2/2 (100)	6/196 (3.1)	2/125 (1.6)	2/40 (5)
Noen U-Loke Mid to Older adults	17/25 (68.0)	10/13 (76.9)	6/8 (75.0)	62/636 (9.7)	43/360 (11.9)	13/206 (6.3)
Ban Non Wat Mid to Older adults	16/29 (55.2)	8/11 (72.7)	7/14 (50)	62/745 (8.3)	31/204 (15.2)	29/195 (14.9)

Table A 8: Bony anomalies in the sample from Ban Non Wat.

BURIAL	LOCATION ON SKELETON	POTENTIAL CAUSE OF ANOMALY
123 Mid adult Male	Right fibula, anterior, proximal shaft	Trauma? Infection at both similar locations on the fibula, but one of which has caused a fracture in one side?
	Left fibula	
126 Mid adult, Unknown Sex	Right tibia, proximal shaft	Soft tissue infection, trauma or skin ulcers.
	Right fibula	
129 Young adult Female	Right rib, lower rib at the angle -	Muscle attachment damage – trauma or activity?
155 Mid adult Male	Left clavicle	Possible fracture of clavicle. Trauma to ligament attachments in pelvis, severe periostitis on legs, muscle attachment lesions on arms. Stressful activities and trauma to bone. Extensive soft tissue infection, trauma or skin ulcers in legs.
	Left pelvis ilium, superior to the acetabulum, margin of gluteus minimus.	
	Right pelvis ilium, superior to the acetabulum, margin of gluteus minimus.	
	Left femur	
	Right femur	
	Left ulna	
	Left radius	
	Right radius	
	Right tibia, majority of shaft	
	Left tibia, majority of shaft	
	Left fibula	
	Right fibula	
	Left 5th metatarsal	
	Right 5th metatarsal	
	Right 1st metatarsal	
159 Mid adult, Male	Left humerus	Minor soft tissue infection or trauma.
185 Mid adult Male	Left femur,	Possibly soft tissue infection, trauma skin ulcers on legs, and Schmorl's nodes indicate strenuous activity.
	Right tibia, posterior, mid shaft, above medial malleolus	
	Right fibula, proximal shaft, posterior side	
	Left tibia, mid shaft, posterior surface	
	Left fibula, Distal shaft, Anterior and medial side	
	Thoracic vertebrae	
186 Older adult Male	Right talus, posterior aspect, lateral tubercle	Cut mark may be post-depositional. Rhomboid fossa. Indicative of manual labour.
	Left clavicle Attachment point for costo-clavicular ligament is prominent	
215 Mid adult Female	Left, occipital Periosteal - Sclerotic reaction,	Scalp wound? Legs – soft tissue infection, trauma or skin ulcers. Arms - inflammation of biceps insertion? Strenuous activity? Legs – strenuous activity, trauma.
	Left tibia, distal shaft, medial side	
	Right tibia, distal shaft, medial side	
	Left radius, proximal shaft, on tuberosity	
	Left fibula. Proximal shaft	
218 Mid adult, Female	Left femur	Soft tissue infection, skin ulcers, trauma.
	Right femur	

BURIAL	LOCATION ON SKELETON	POTENTIAL CAUSE OF ANOMALY
229 Mid adult Unknown Sex	Left rib, attachment point for scalenus posterior.	. Trauma injury?
231 Mid adult Male	Right scapula suprascapular notch and superior border	Normal – Congenitial.
265 Mid adult, Male	Left tibia	Leg – trauma- activity. Foot – Trauma.
	Right 2nd metatarsal, mid shaft.	
325 Young adult, Male	Right 2nd metacarpal, proximal epiphysis	Hands – trauma. Knee – trauma – activity. Femur - The holes suggest a weapon or natural occurrence - such as borer insect or root.
	Left 3rd metacarpal	
	Right patella	
	Left patella	
	Left femur, distal shaft, medial and lateral side	
334 Young adult Female	Left patella, between the tendon attachment points of the quadriceps on anterior surface.	Activity, trauma.
360 Mid adult, Unknown Sex	Left mandible	Peri- or post mortem occurrence – cut mark.
	Left humerus, distal epiphysis, anterior view	
367 Young adult Male	Vertebral body	Soft tissue infection, trauma or skin ulcer.
382 Mid adult, Unknown sex	Left tibia, anterior surface of distal epiphysis	Soft tissue infection, activity, trauma or skin ulcer.
392 Mid adult, Male	Left clavicle, proximal shaft, costo-clavicular ligament attachment	Clavicle: Rhomboid fossa. Indicative of manual labour. Trauma. Lower legs: Trauma, infection. Tibia: possible osteoid osteoma.
	Right fibula, proximal shaft, lateral side, extending into the epiphysis	
	Left tibia, distal shaft, medial surface close to epiphysis	
	Right tibia, distal shaft, lateral surface close to epiphysis	
407 Older adult, Female	Left patella, close to the articular surface	Knee –Activity, trauma. Femur – congenital.
	Right patella, close to the articular surface	
	Left, Femur.proximal shaft	
	Right femur, proximal shaft	
408 Older adult, Male	Right clavicle, sternal end - upper side, epiphysis	Clavicle:Rhomboid fossa. Indicative of manual labour. Trauma?
415 Young adult, sex unknown	Left radius, distal epiphysis, cortex and cancellous bone on edge of epiphysis	Infection, trauma.
419 Young adult, Female	Right distal fibula, medial side	Infection, trauma.
431 Older adult, Male	Left parietal bone, near sagittal suture	Skull – post depositional damage? Arm – Trauma.
	Right ulna,distal shaft	
449 Young adult, Female	Right temporal bone	Trauma.
	Left femur, proximal epiphysis,lateral side	

BURIAL	LOCATION ON SKELETON	POTENTIAL CAUSE OF ANOMALY
474 Young adult, Female	Left hamate -non articular – dorsal surface	Infection, trauma.
	Right distal ulna, along the epiphyseal boundary on the ulna	
535 Mid adult, Female	Left ulna, styloid process	Trauma, infection.
	Left tibia, medial surface	
	Right tibia, medial surface	
	Right 2nd metatarsal, mid shaft, anterior	
539 Mid adult Male	Left clavicle	Trauma, activity.
	Sternum	
	Left femur	
	Left pelvis	
549 Mid adult, Male	Left lateral, sternum, anterior side	Trauma, infection.
	Frontal bone	
	Left 5th metacarpal, medial side, proximal shaft	
554 Mid adult, Female	Right radius, mid shaft, along the inter-osseous border.	Trauma, infection.
	Right fibula, middle shaft, lateral view, next to the inter-osseous border.	
	Right tibia, lateral surface, proximal shaft	
	Right distal ulna, frontal view. 11mm beneath area affected by fracture.	
	Right ulna, mid shaft, all aspects	
	Right 3rd metatarsal, mid shaft	
	Right 4th metatarsal	
	Right, 5th metatarsal	
	Left 5th metatarsal	
	Left 4th metatarsal	

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Table A 9: Mean length (mm) of long bones from Bronze and Iron Age sites in northeast Thailand and regional means. Ban Chiang data obtained from Pietrusewsky and Toomay (2002a), the Non Nok Tha database from Douglas (1996a), and the Ba Na Di and Ban Lum Khao databases (K. Domett, pers. comm).

Site	Sex	Left Clavicle	Right Clavicle	Left Humerus	Right Humerus	Left Radius	Right Radius	Left Ulna	Right Ulna	Left Femur	Right Femur	Left Tibia	Right Tibia	Left Fibula	Right Fibula
Ban Na Di	F	128		279		229.82		257.4		419.86		347.17			
	M	142.15		314.7		253.71		288.5		464.75		394.4		379.33	
Ban Chiang	F	133.38	130.71	286.5	288.4	230.25	228.6	252.33	240.5	410.75	404	347.5	346	335.5	338.67
	M	146.92	146.18	307.36	311.17	251.67	252	272.57	269.42	447.58	441.13	379.75	375.85	363.71	360.18
Non Nok Tha	F	126.5	129.125	282	282.3	227.44	224.5	247	253.2	406.9	405.64	354.67	342.22	342.5	335.57
	M	143.92	141.75	306.89	308.27	253.82	253.1	266.7	273.71	441.69	439.9	376.58	376.36	361.29	361.5
Ban Lum Khao	F	126	128.5	289	291	231	226	254	249.33	406.5	410.67	341	340.25	339	349.33
	M	157.67	150	304.5	318	235.33	253.5	280.5	259	461.5	459.33	395	385.75	368	377.33
Ban Non Wat	F	130.8	125.17	293.71	305.75	235.33	238.75	255.67	255.5	416	424	351.75	351.8	353.5	363.25
	M	152.2	154.33	322.06	332.29	263.67	267.67	284.75	276	461	466.2	399.6	387.92	387	424
Noen U-Loke	F	136.47	128.12	291.67	299.7	237	237.33	257	250.5	423.5	402.7	366.67	357	353	330
	M	142.93	145.62	322.63	324	258.83	251.57	290.5	268.6	460.14	457.25	389.88	385	372	369
Mean NE Thailand Not including Ban Non Wat and Noen U-Loke	F	128.83	127.96	287.43	287.16	229.39	226.95	251.12	248.13	412.03	406.29	346.74	343.38	337.6	338.66
	M	145.60	143.5	309.03	309.32	251.10	250.74	272.79	270.33	447.88	438.70	378.67	373.30	363.09	363.33
Ban Non Wat and Noen U-Loke - % of NE Thailand mean															
Ban Non Wat	F	101.53	97.82	102.18	106.47	102.59	105.20	101.81	102.97	100.96	104.36	101.44	102.45	104.71	107.26
	M	104.53	107.55	104.22	107.43	105.01	106.75	104.38	102.10	102.93	106.27	105.53	103.92	106.59	116.70
Noen U-Loke	F	105.93	100.13	101.48	104.37	103.32	104.57	102.34	100.96	102.78	99.12	105.75	103.97	104.56	97.44
	M	98.17	101.48	104.40	104.75	103.08	100.33	106.49	99.36	102.74	104.23	102.96	103.13	102.45	101.56

Table A 10: Long bone lengths (mm) from the male sample at Ban Non Wat.

Burial No	Left Clavicle	Right Clavicle	Left Humerus	Right Humerus	Left Radius	Right Radius	Left Ulna	Right Ulna	Left Femur	Right Femur	Left Tibia	Right Tibia	Left Fibula	Right Fibula
123				332				267						
155		151												
159					263		280		443	442				
185	164	161	364	366	294	293	310		514	509	446	443		424
186			308											
210	149	148	335.5	334	265		283	285	457			393.5	380	
265			324							485	394			
325			280									334		
390	156								440		388			
392			318	321	246	250	266			439	361	362		
408	140		326	319					451					
431		156			260	260						389		
539		167		339						456	409	406	394	
549	152	143	321	315	254									
Mean	152.200	154.333	322.063	332.286	263.667	267.667	284.750	276.000	461.000	466.200	399.600	387.917	387.000	424.000
Std Dev	8.843	8.802	23.734	17.260	16.379	22.502	18.392	12.728	30.373	30.062	31.214	37.342	9.900	-

Table A 11: Long bone lengths (mm) from the female sample at Ban Non Wat.

Burial No	Left Clavicle	Right Clavicle	Left Humerus	Right Humerus	Left Radius	Right Radius	Left Ulna	Right Ulna	Left Femur	Right Femur	Left Tibia	Right Tibia	Left Fibula	Right Fibula
129					240		262	264			350			
215			307	302	248					422		365	356	379
218		118	285								337	334		
227											367			
334	135.5	130.5	287	292	223	222		250						
416												360		378
419			297											
474	128					237	251		430	426				346
535			288		237		254							
554			296		231				402			344		350
433				331		258		248						
449	128.9	127	296	298	233	238		260			353	356	351	
Mean	130.800	125.167	293.714	305.750	235.333	238.750	255.667	255.500	416.000	424.000	351.750	351.800	353.500	363.250
Std Dev	4.095	6.449	7.653	17.328	8.501	14.773	5.686	7.724	19.799	2.828	12.311	12.617	3.535	17.689

Table A 12: Male adult individuals from Noen U-Loke - long bone length (mm).

Burial No	Left Clavicle	Right Clavicle	Left Humerus	Right Humerus	Left Radius	Right Radius	Left Ulna	Right Ulna	Left Femur	Right Femur	Left Tibia	Right Tibia	Left Fibula	Right Fibula
1				316		244	300							
5			334		260						401			
14			315	326	239	242		267						
26		137.7		315	259	259	287	286	461	459	372	376		371
27	153.7	142.1	307	308	244			266	456	450	364	364	367	
32								267						
33		161	312	317		254								
39				320										
42			341	340	277		299			494		424		
44			318	319					459			391	377	378
45											402			
50				335							417	416		
60						243						370		
61							276		422	416				
66											379	376		
68														358
69	144			323					455	456	383	382		
74		165	339	336		265			485	481		395		
94	155			340	274									
98										432		338		
107	119	122.3	315	317		254		257	483	470	401	403		
Mean	142.925	145.620	322.625	324.000	258.833	251.571	290.500	268.600	460.143	457.250	389.875	385.000	372.000	369.000
Std Dev	16.688	17.543	13.255	10.496	15.329	8.848	11.328	10.597	20.980	25.280	18.067	24.470	7.071	10.149

Table A 13: Long bone lengths (mm) recorded in female adult individuals from Noen U-Loke.

Burial No	Left Clavicle	Right Clavicle	Left Humerus	Right Humerus	Left Radius	Right Radius	Left Ulna	Right Ulna	Left Femur	Right Femur	Left Tibia	Right Tibia	Left Fibula	Right Fibula
110				293										
113				317					452		366			
62		107		281								331		
108	138	134.1	308	312	252	254		263			369			
10				320										
30				300		225	257			420.4		368		
35				294						385				
36		134	283	300		233								
37	131.4	134	284	291					395					
40				289				238				372		330
99	140	131.5			222						365		353	
Mean	136.467	128.120	291.667	299.700	237.000	237.333	257.000	250.500	423.500	402.700	366.667	357.00	353.000	330.000
Std Dev	4.500	11.857	14.154	12.824	21.213	14.978	-	17.678	40.305	25.032	2.082	22.605	-	-

Table A 14: Enamel Hypoplasias identified in the Ban Non Wat sample.

Burial	Sex	Phase	MANDIBLE						MAXILLA									
			1st Pre-molar	Canine	2nd Incisor	1st Incisor	2nd Incisor	Canine	2nd Molar	1st Pre-molar	Canine	2nd Incisor	1st Incisor	1st Incisor	2nd Incisor	Canine	1st Pre-molar	1st Molar
			Right			Left			Right					Left				
123	Male	Late Bronze	Confluent pits	Confluent pits					Single transverse line	Single transverse line	2 or more transverse lines					Single pit	Single pit	
186	Male	Late Bronze		Confluent pits			Single transverse line	Single transverse line										
210	Male	Mid Bronze						2 or more transverse lines										
215	Female	Late Bronze		Confluent pits				Confluent pits				2 or more transverse lines			2 or more transverse lines			2 or more transverse lines
218	Female	Late Bronze		Single transverse line	Single transverse line	Single transverse line	Single transverse line	Single transverse line			Single transverse line	Single transverse line	Single transverse line	Single transverse line	Single transverse line	Single transverse line		
392	Male	Mid Bronze		Confluent pits				Confluent pits										
415	Unknown	Early Iron									2 or more pits					Single pit		
549	Male	Mid Bronze		Single transverse line				Single pit								Single pit		

Table A 15: Prevalence of enamel hypoplasias in Ban Non Wat and Noen U-Loke (based on raw data).

	BAN NON WAT		NOEN U-LOKE	
	No of teeth			
	%	a/n	%	a/n
Male	4.1	16/386	9.4	30/320
Female	4.5	16/352	12.1	37/306
Total Sample	4.0	34/860	10.7	77/722
	No of individuals			
	%	i/t	%	i/t
Males	31	5/16	54.5	12/22
Females	11.8	2/17	52.6	10/19
Total	21	8/38	53.1	26/49

*a = affected with enamel hypoplasia, n = number of teeth observed, i = individuals affected, t = number of total individuals

Table A 16: Non-vertebral joint bony anomalies in sample from Ban Non Wat.

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
129 Young Female	Knee Left Femur	Complete	Barely discernible			Sharp boundary
	Knee Right Femur	>1/2	Barely discernible			Sharp boundary
155 Mid Male	Hip Right Acetabulum	Complete	Barely discernible			
	Hip Right Femur	>1/2	N/A	Pinpoint		
	Knee Right Femur	>1/2		Both pinpoint and coalesced		
	Knee Left Femur	<1/2		Both pinpoint and coalesced		
	Hip Left Femur	Complete		Pinpoint		
	Elbow Left Radius	>1/2		Pinpoint		
	Elbow Left Ulna	Complete		Pinpoint		
	Shoulder Right Scapula	>1/2	Sharp ridge, sometimes curled with spicules	Pinpoint		
	Shoulder Right Humerus	Complete		Both pinpoint and coalesced		
	Elbow Right Humerus	Complete		Both pinpoint and coalesced		

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Elbow Right Radius	Complete		Pinpoint		
	Ankle Right Tibia	>1/2		Both pinpoint and coalesced		
	Knee Right Tibia	>1/2		Coalesced		
	Ankle Left Talus	Complete		Pinpoint		
	Shoulder Left Scapula	Complete	Sharp ridge, sometimes curled with spicules	Pinpoint		
	Shoulder Left Humerus	Complete		Pinpoint		
	Wrist Left Lunate	Complete		Pinpoint		
	Wrist Right Lunate	>1/2		Both pinpoint and coalesced		
	Elbow Left Humerus	>1/2		Both pinpoint and coalesced		
	Ankle Right Talus	Complete		Both pinpoint and coalesced		
159 Mid Male	Ankle Left Tibia	Complete	Sharp ridge, sometimes curled with spicules			
	Ankle Right Tibia	Complete	Sharp ridge, sometimes curled with spicules			

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
186 Older Male	Ankle Left Talus	Complete		Both pinpoint and coalesced		
	Shoulder Left Humerus	>1/2		Pinpoint		
	Elbow Left Humerus	Complete		Pinpoint		
210 Older Male	Shoulder Right Scapula	Complete	Sharp ridge, sometimes curled with spicules			
215 Mid Female	Shoulder Left Scapula	>1/2	Sharp ridge, sometimes curled with spicules			On the upper edge
	Shoulder Left Scapula	Complete	Sharp ridge, sometimes curled with spicules			On the upper edge
	Hip Right Acetabulum	<1/2	Sharp ridge, sometimes curled with spicules			
	Shoulder Right Humerus	Complete	Barely discernible			
	Elbow Right Humerus	Complete	Sharp ridge, sometimes curled with spicules			
	Elbow Left Ulna	Complete	Sharp ridge, sometimes curled with spicules			
	Wrist Right Radius	Complete	Sharp ridge, sometimes curled with spicules			
218 Mid Female	Wrist Right Ulna	Complete	Barely discernible		Barely discernible	
229 Mid Unknown Sex	Elbow Left Radius	>1/2		Pinpoint		On articulation with ulna

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Elbow Right Radius	>1/2		Pinpoint		On articulation with ulna
237 Mid Female	Shoulder Right Scapula	<1/2	Sharp ridge, sometimes curled with spicules			
	Hip Left Acetabulum	<1/2	Sharp ridge, sometimes curled with spicules			
323 Older Female	Wrist Left Scaphoid	Complete				Two grooves are located on the articular surface with the radius.
334 Young Female	Shoulder Right Humerus	>1/2	Barely discernible			Small section of minor lipping on edge of trochlea.
	Elbow Right Humerus	>1/2	Barely discernible			Small section of minor lipping on edge of trochlea.
	Wrist Left Radius	Complete	Barely discernible			Minor lipping where the lunate articulates.
	Hip Left Acetabulum	<1/2	Barely discernible			Lipping (wide) visible although minor-
	Ankle Right Tibia	Complete	Barely discernible			Very minor lipping at articulation with talus.
367 Young Male	Elbow Left Ulna	>1/2	Sharp ridge, sometimes curled with spicules			Minor lipping - sharp. On the olecranon.
	Elbow Right Ulna	<1/2	Sharp ridge, sometimes curled with spicules			Minor lipping - sharp. On the olecranon.
	Hip Right Acetabulum	<1/2	Sharp ridge, sometimes curled with spicules			No spicules, just a sharp ridge.
	Knee Right Femur	>1/2	Barely discernible	Coalesced		One large pore and minor lipping.

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Knee Left Fibula	>1/2	Sharp ridge, sometimes curled with spicules			Sharp lip on the styloid process.
382 Mid Unknown Sex	Elbow Left Radius	>1/2		Pinpoint		Some porosity around the margins of the head of the radius
	Left Patella	<1/2	Sharp ridge			The edge has marked lipping. Not all of the articular surface has survived. Indication of joint disease.
	Ankle Left Tibia	<1/2	Barely discernible	Both pinpoint and coalesced		Only a small section of the articulation survives. It has some minor lipping around the anterior margin.
383 Mid Female	Knee Right Femur	<1/2	Barely discernible			
	Metatarsal Left	Complete	Clearly present			
390 Mid Male	Knee Left Femur	>1/2		Pinpoint		Upper cortex loss and remodelling of lower cortical bone, which has pinpoint porosity and an uneven surface.
392 Mid Male	Elbow Left Humerus	Complete	Barely discernible			
	Elbow Right Humerus	Complete	Barely discernible			
407 Older Female	Shoulder Left Scapula	>1/2	Barely discernible	Pinpoint		
	Shoulder Right Scapula	Complete	Barely discernible			
	Shoulder Right Humerus	<1/2		Both pinpoint and coalesced		
	Elbow Right Humerus	>1/2	Barely discernible	Pinpoint	Clearly present	

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Wrist Left Ulna	Complete		Both pinpoint and coalesced		
	Elbow Right Radius	>1/2		Pinpoint		
	Elbow Right Ulna	Complete	Sharp ridge, sometimes curled with spicules	N/A		
	Wrist Right Lunate	Complete		Pinpoint		
	Wrist Left Lunate	Complete		Pinpoint		
	Wrist Left Scaphoid	Complete	Barely discernible	Pinpoint		
	Hip Left Femur	>1/2		Both pinpoint and coalesced		
	Hip Right Femur	>1/2		Coalesced		
	Knee Left Femur	>1/2	Barely discernible	Pinpoint	Clearly present	
	Knee Right Femur	>1/2	Barely discernible	Pinpoint	Clearly present	
	Ankle Right Tibia	>1/2	Barely discernible			
	Ankle Right Talus	Complete		Both pinpoint and coalesced		
	Ankle Left Talus	Complete		Both pinpoint and coalesced		

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
408 Older Male	Shoulder Left Scapula	>1/2	Barely discernible			
	Wrist Left Ulna	Complete	Barely discernible			
415 Young Unknown Sex	Shoulder Right Scapula	<1/2		Both pinpoint and coalesced	Barely discernible	The surface has three pits. Osteophytes are located within the upper mid section - not along the edges.
	Wrist Left Radius	>1/2		Pinpoint		
419 Young Female	Elbow Left Humerus	<1/2		Both pinpoint and coalesced		Only a fragment of the articulation remains. The densest concentration is located on the trochlea, two other isolated areas of porosity also visible, but contain 1 pinpoint and the other 3 close together.
	Shoulder Head Right Humerus	>1/2		Pinpoint		A large portion of the surviving articular surface is covered in concretions.
	Elbow Lateral epicondyle Right Humerus	>1/2		Pinpoint		Only a small section of the articulation has pinpoint pitting. It extends from the edge of the lateral epicondyle to the middle of the epiphysis, where the trochlea begins.
	Wrist Head Left Ulna	>1/2		Both pinpoint and coalesced		Concretions cover some of the articular surface, but the only visible porosity is located on the head.
	Elbow Head Left Radius	>1/2		Pinpoint		Concretions cover some of the articular surface, but the only visible porosity is located on the head. There are 2 pinpoints also by a damaged area away from the main concentration.

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Wrist Right- radius articulation Lunate	Complete		Both pinpoint and coalesced		Some porosity on the articulation with the radius.
	Knee Left Femur	<1/2		Pinpoint		Remains are fragmentary. One fragment of condyle shows porosity.
	Knee Right Femur	<1/2		Pinpoint		Remains are fragmentary. One fragment of condyle shows porosity. Much of the surface has concretions.
	Knee Left lateral condyle, interior edge of articulation. Tibia	<1/2	Barely discernible			Two small areas of minor lipping, separated by damage. It is assumed that these two areas were once joined. The 5mm lipping abuts a fracture and may have extended further.
431 Older Male	Shoulder Left Scapula	>1/2	Sharp ridge, sometimes curled with spicules			
	Hip Right Acetabulum	Complete	Barely discernible			
	Hip Right Femur	Complete		Pinpoint		
	Hip Right Acetabulum	Complete	Barely discernible			
	Wrist Left Radius	Complete	Barely discernible			
	Elbow Right Ulna	>1/2	Sharp ridge, sometimes curled with spicules			
	Elbow Right Humerus	Complete	Sharp ridge, sometimes curled with spicules			

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
	Shoulder Right Humerus	Complete	Barely discernible			
	Shoulder Left Humerus	Complete	Barely discernible			
	Elbow Left Ulna	>1/2	Sharp ridge, sometimes curled with spicules			
	Wrist Right Ulna	>1/2	Barely discernible			
449 Young Female	Shoulder Left Scapula	Complete		Pinpoint	Barely discernible	
	Shoulder Right Scapula	Complete	Barely discernible	Pinpoint	Clearly present	
	Hip Left Femur	Complete		Both pinpoint and coalesced		
	Hip Left Acetabulum	Complete			Barely discernible	The femoral head covers a large portion of the surface.
	Hip Right Acetabulum	Complete		Pinpoint	Barely discernible	
	Elbow Left Humerus	Complete	Barely discernible	Pinpoint		
	Elbow Right Radius	Complete		Pinpoint		
	Knee Right Femur	>1/2	Barely discernible	Pinpoint		
	Knee Left Femur	>1/2		Pinpoint		

BURIAL	JOINT SURFACE ELEMENT	ARTICULAR SURFACE	DEGREE OF LIPPING	DEGREE OF POROSITY	OSTEOPHYTES	COMMENTS
474 Young Female	Hip Right Acetabulum	>1/2	Barely discernible			
535 Mid Female	Wrist Left Lunate	Complete	Barely discernible			
	Elbow Left Radius	Complete		Pinpoint		
	Shoulder Left Humerus	>1/2		Pinpoint		
	Elbow Left Humerus	>1/2		Pinpoint		
549 Mid Male	Shoulder Right Humerus	Complete		Both pinpoint and coalesced		Porosity is concentrated on the peak of the articulation
	Wrist Left Radius	>1/2		Coalesced		Concentrated in centre of articulation.
	Hip Left Femur	Complete		Pinpoint		Not obvious

Table A 17: Vertebral joint bony anomalies in the sample from Ban Non Wat.

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
129	Lumbar	Superior	1	<1/2	Slight
129	Upper Thoracic	Superior	1	>1/2	Moderate
129	Upper Thoracic	Inferior	1	<1/2	Moderate
129	Upper Thoracic	Superior	2	<1/2	Slight
129	Upper Thoracic	Superior	6	>1/2	Slight
129	Upper Thoracic	Inferior	2	>1/2	Slight
129	Lower Thoracic	Superior	1	<1/2	Slight
129	Lower Thoracic	Superior	1	>1/2	Slight
129	Lower Thoracic	Superior	1	<1/2	Slight
129	Lower Thoracic	Inferior	1	>1/2	Slight
129	Lower Thoracic	Superior	1	>1/2	Slight
155	Cervical	Superior	1	Complete	Slight
155	Cervical	Inferior	1	Complete	Slight
155	Upper Thoracic	Inferior	1	Complete	Slight
155	Upper Thoracic	Superior	1	>1/2	Moderate
155	Upper Thoracic	Inferior	1	>1/2	Slight
155	Upper Thoracic	Superior	1	<1/2	Slight
155	Lower Thoracic	Superior	1	>1/2	Slight
155	Lower Thoracic	Inferior	2	<1/2	Slight
155	Lower Thoracic	Superior	1	<1/2	Slight
159	Lumbar	Superior	1	Complete	Severe
159	Lumbar	Inferior	1	<1/2	Slight
159	Lumbar	Superior	1	<1/2	Moderate
159	Lumbar	Inferior	1	<1/2	Moderate
159	Lumbar	Inferior	3	Complete	Slight
159	Lumbar	Superior	3	Complete	Moderate
159	Lower Thoracic	Inferior	1	Complete	Severe
159	Lower Thoracic	Superior	1	Complete	Slight
159	Lower Thoracic	Inferior	2	Complete	Slight
185	Cervical	Superior	1	Complete	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
185	Cervical	Superior	1	<1/2	Slight
185	Cervical	Inferior	2	<1/2	Slight
185	Upper Thoracic	Superior	4	Complete	Slight
185	Upper Thoracic	Inferior	2	Complete	Slight
185	Upper Thoracic	Inferior	2	>1/2	Slight
185	Upper Thoracic	Inferior	1	<1/2	Slight
185	Lower Thoracic	Superior	4	Complete	Slight
185	Lower Thoracic	Inferior	3	Complete	Slight
185	Lower Thoracic	Inferior	1	<1/2	Slight
185	Lower Thoracic	Superior	1	<1/2	Slight
185	Lower Thoracic	Superior	1	>1/2	Slight
185	Lumbar	Superior	4	Complete	Slight
185	Lumbar	Inferior	3	Complete	Slight
185	Lumbar	Inferior	1	<1/2	Slight
185	Lumbar	Superior	1	<1/2	Slight
186	Cervical	Superior	1	<1/2	Slight
186	Cervical	Inferior	2	Complete	Slight
186	Cervical	Superior	1	Complete	Slight
186	Cervical	Superior	2	>1/2	Slight
186	Cervical	Inferior	1	<1/2	Slight
210	Cervical	Superior	1	>1/2	Slight
210	Upper Thoracic	Inferior	1	<1/2	Slight
210	Lower Thoracic	Inferior	1	<1/2	Slight
210	Lower Thoracic	Superior	1	<1/2	Moderate
210	Lower Thoracic	Superior	1	>1/2	Slight
210	Lower Thoracic	Inferior	1	>1/2	Slight
210	Lumbar	Superior	1	<1/2	Slight
210	Lumbar	Superior	1	<1/2	Moderate
210	Lumbar	Inferior	1	<1/2	Severe
210	Lumbar	Inferior	1	>1/2	Slight
215	Cervical	Superior	1	<1/2	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
215	Cervical	Superior	2	>1/2	Slight
215	Cervical	Inferior	1	>1/2	Moderate
215	Upper Thoracic	Inferior	2	>1/2	Slight
215	Upper Thoracic	Inferior	4	<1/2	Slight
215	Upper Thoracic	Superior	2	<1/2	Slight
215	Lower Thoracic	Superior	1	Complete	Slight
218	Cervical	Inferior	1	Complete	Slight
218	Cervical	Superior	1	Complete	Slight
218	Upper Thoracic	Superior	1	>1/2	Slight
218	Upper Thoracic	Inferior	1	>1/2	Slight
218	Upper Thoracic	Superior	1	Complete	Slight
218	Upper Thoracic	Inferior	1	Complete	Slight
218	Upper Thoracic	Superior	1	Complete	Moderate
218	Lower Thoracic	Superior	1	Complete	Moderate
218	Lower Thoracic	Inferior	2	Complete	Slight
218	Lower Thoracic	Superior	1	Complete	Slight
227	Upper Thoracic	Superior	1	Complete	Slight
227	Lower Thoracic	Inferior	1	Complete	Slight
227	Lower Thoracic	Superior	1	Complete	Slight
227	Lumbar	Superior	1	Complete	Slight
227	Lower Thoracic	Superior	1	>1/2	Slight
229	Cervical	Inferior	2	Complete	Slight
229	Lumbar	Superior	1	<1/2	Slight
231	Lower Thoracic	Superior	2	<1/2	Slight
231	Lower Thoracic	Inferior	1	<1/2	Slight
237	Cervical	Superior	2	<1/2	Slight
237	Cervical	Inferior	2	<1/2	Slight
265	Upper Thoracic	Superior	2	Complete	Slight
265	Cervical	Inferior	1	Complete	Slight
265	Lumbar	Inferior	1	Complete	Slight
325	Upper Thoracic	Superior	1	<1/2	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
325	Lumbar	Superior	1	<1/2	Slight
325	Lumbar	Inferior	1	<1/2	Slight
334	Cervical	Inferior	1	Complete	Slight
334	Cervical	Superior	1	Complete	Slight
334	Cervical	Superior	1	<1/2	Slight
334	Cervical	Inferior	1	<1/2	Slight
334	Upper Thoracic	Inferior	2	<1/2	Moderate
334	Upper Thoracic	Superior	1	<1/2	Slight
334	Upper Thoracic	Inferior	1	<1/2	Slight
334	Lower Thoracic	Superior	2	<1/2	Moderate
334	Lower Thoracic	Inferior	1	Complete	Moderate
367	Lumbar	Superior	1	<1/2	Moderate
380	Upper Thoracic	Superior	2	>1/2	Slight
380	Upper Thoracic	Inferior	2	>1/2	Slight
380	Lower Thoracic	Superior	1	<1/2	Moderate
392	Cervical	Inferior	1	>1/2	Slight
392	Cervical	Inferior	1	Complete	Slight
392	Upper Thoracic	Superior	1	<1/2	Slight
392	Upper Thoracic	Inferior	2	<1/2	Slight
392	Upper Thoracic	Inferior	1	>1/2	Slight
392	Upper Thoracic	Superior	1	Complete	Slight
392	Upper Thoracic	Superior	1	Complete	Moderate
392	Upper Thoracic	Inferior	2	Complete	Moderate
392	Upper Thoracic	Superior	1	>1/2	Slight
392	Lower Thoracic	Superior	3	Complete	Slight
392	Lower Thoracic	Inferior	3	Complete	Slight
392	Lower Thoracic	Superior	1	<1/2	Slight
392	Lower Thoracic	Inferior	2	>1/2	Slight
392	Lower Thoracic	Superior	1	Complete	Moderate
392	Lower Thoracic	Superior	1	>1/2	Slight
392	Lower Thoracic	Inferior	1	<1/2	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
392	Lumbar	Superior	2	<1/2	Slight
392	Lumbar	Inferior	3	Complete	Slight
392	Lumbar	Superior	2	Complete	Slight
392	Lumbar	Superior	1	>1/2	Moderate
392	Lumbar	Inferior	1	<1/2	Slight
407	Cervical	Superior	2	Complete	Moderate
407	Cervical	Superior	2	Complete	Slight
407	Cervical	Inferior	1	Complete	Moderate
407	Cervical	Inferior	2	<1/2	Moderate
407	Cervical	Superior	1	<1/2	Moderate
408	Cervical	Inferior	1	Complete	Slight
408	Cervical	Superior	1	>1/2	Slight
408	Upper Thoracic	Inferior	1	<1/2	Slight
408	Upper Thoracic	Inferior	1	>1/2	Slight
408	Upper Thoracic	Superior	3	>1/2	Slight
408	Lower Thoracic	Superior	3	Complete	Slight
408	Lower Thoracic	Inferior	1	Complete	Slight
408	Lower Thoracic	Inferior	2	>1/2	Slight
408	Lower Thoracic	Superior	1	>1/2	Slight
408	Lumbar	Superior	2	Complete	Slight
408	Lumbar	Inferior	1	Complete	Slight
408	Lumbar	Inferior	1	>1/2	Slight
408	Lumbar	Superior	1	<1/2	Moderate
408	Lumbar	Inferior	1	<1/2	Moderate
416	Cervical	Superior	1	<1/2	Slight
416	Cervical	Inferior	2	<1/2	Slight
431	Cervical	Superior	1	>1/2	Slight
431	Cervical	Inferior	1	Complete	Slight
431	Upper Thoracic	Superior	2	Complete	Slight
431	Upper Thoracic	Inferior	2	Complete	Slight
431	Upper Thoracic	Inferior	1	<1/2	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
431	Upper Thoracic	Superior	1	>1/2	Moderate
431	Upper Thoracic	Inferior	1	>1/2	Moderate
431	Lower Thoracic	Superior	3	Complete	Slight
431	Lower Thoracic	Inferior	3	Complete	Slight
431	Lumbar	Inferior	3	<1/2	Slight
431	Lumbar	Superior	2	<1/2	Slight
431	Lumbar	Superior	1	>1/2	Slight
431	Lumbar	Superior	1	>1/2	Moderate
431	Lumbar	Inferior	1	>1/2	Moderate
431	Lumbar	Superior	1	Complete	Slight
431	Lumbar	Inferior	1	Complete	Slight
433	Cervical	Superior	3	<1/2	Slight
433	Cervical	Superior	1	>1/2	Slight
439	Lower Thoracic	Superior	1	>1/2	Slight
439	Lower Thoracic	Inferior	1	>1/2	Slight
439	Lumbar	Superior	1	<1/2	Moderate
439	Lumbar	Inferior	2	<1/2	Moderate
439	Lumbar	Superior	2	<1/2	Slight
439	Lumbar	Inferior	1	<1/2	Slight
439	Lumbar	Superior	1	>1/2	Slight
439	Lumbar	Inferior	1	>1/2	Slight
449	Cervical	Superior	2	>1/2	Slight
449	Cervical	Inferior	2	Complete	Slight
449	Cervical	Superior	3	Complete	Slight
449	Cervical	Inferior	1	Complete	Moderate
449	Cervical	Inferior	2	>1/2	Slight
449	Upper Thoracic	Superior	1	Complete	Slight
449	Upper Thoracic	Superior	1	<1/2	Slight
449	Upper Thoracic	Inferior	3	<1/2	Slight
449	Upper Thoracic	Superior	2	>1/2	Slight
449	Upper Thoracic	Superior	1	>1/2	Slight

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
449	Upper Thoracic	Inferior	2	>1/2	Slight
449	Lower Thoracic	Superior	1	<1/2	Slight
449	Lower Thoracic	Inferior	2	>1/2	Slight
449	Lower Thoracic	Superior	4	Complete	Slight
449	Lower Thoracic	Inferior	4	Complete	Slight
449	Lower Thoracic	Superior	1	>1/2	Slight
449	Lumbar	Superior	3	Complete	Slight
449	Lumbar	Inferior	3	Complete	Slight
535	Cervical	Inferior	1	Complete	Slight
535	Upper Thoracic	Inferior	1	<1/2	Slight
535	Upper Thoracic	Superior	3	<1/2	Slight
535	Upper Thoracic	Inferior	2	<1/2	Slight
535	Lumbar	Superior	1	<1/2	Slight
535	Lumbar	Inferior	1	<1/2	Moderate
539	Lumbar	Superior	1	<1/2	Slight
539	Lumbar	Inferior	1	<1/2	Slight
539	Lower Thoracic	Superior	2	<1/2	Slight
539	Upper Thoracic	Superior	1	<1/2	Slight
539	Upper Thoracic	Inferior	1	<1/2	Slight
549	Cervical	Superior	1	>1/2	Slight
549	Cervical	Inferior	1	<1/2	Slight
549	Upper Thoracic	Superior	3	<1/2	Slight
549	Upper Thoracic	Inferior	3	<1/2	Slight
549	Lower Thoracic	Superior	1	>1/2	Slight
549	Lower Thoracic	Superior	1	<1/2	Slight
549	Lower Thoracic	Inferior	1	<1/2	Slight
549	Lumbar	Inferior	2	<1/2	Slight
554	Cervical	Superior	3	Complete	Slight
554	Cervical	Inferior	3	Complete	Slight
554	Upper Thoracic	Superior	3	Complete	Slight
554	Upper Thoracic	Inferior	2	Complete	Moderate

BURIAL	VERTEBRAE	SURFACE	NO SURFACES	VISIBLE	DEGREE OF OSTEOARTHRITIS
554	Upper Thoracic	Inferior	2	Complete	Slight
554	Upper Thoracic	Superior	1	Complete	Moderate
554	Lumbar	Inferior	2	>1/2	Slight
554	Lumbar	Superior	2	>1/2	Slight
554	Lumbar	Superior	1	Complete	Slight
554	Lumbar	Inferior	2	Complete	Slight

Table A 18: Vertebral bodies with osteoarthritis indicators, Ban Non Wat.

BURIAL	NO. VERTEBRAL BODY SURFACES WITH SLIGHT OA (> ½ SURFACE VISIBLE)	NO. VERTEBRAL BODY SURFACES WITH MODERATE OA (> ½ SURFACE VISIBLE)	NO. VERTEBRAL BODY SURFACES WITH SEVERE OA (> ½ SURFACE VISIBLE)	COMMENTS
129	11	1	-	Lipping is porous, osteophytes on lipping and body surface, lipping, pitting
155	5	1	-	
159	6	3	2	
185	23	-	-	Lipping porosity, lipping, pitting
186	5	-	-	
210	4	-	-	
215	5	1	-	Lipping spur – 4mm long
218	9	2	-	
227	5	-	-	
229	2	-	-	Lipping, sharp lip
231	-	-	-	Fragments have evidence of OA
237	-	-	-	Fragments have pitting, lipping
265	4	-	-	Lipping and osteophytes
325	-	-	-	Fragments have evidence of OA
334	2	1	-	
367	-	-	-	Fragments have evidence of OA
380	4	-	-	
392	19	5	-	
407	2	3	-	
408	17	-	-	
416	-	-	-	Fragments have evidence of OA
431	15	4	-	
433	1	-	-	
439	4	-	-	Some lipping and osteophytes, moderate size osteophyte on margins, lipping – smooth, wide lip, porosity, sharp lipping, large osteoclastic hole.
449	32	1	-	
535	1	-	-	
539	-	-	-	Fragments have evidence of OA
549	2	-	-	Osteophytes on body, lipping, pitting, spurs, small spurs
554	18	3	-	Slight lipping, osteophytes, lipping, pitting on lipping

Table A 19: Summary of DJD in joints and vertebrae in the sample from Ban Non Wat.

BURIAL	NON-VERTEBRAL JOINTS AFFECTED	NO. VERTEBRAL BODY SURFACES WITH OA (> ½ SURFACE VISIBLE)	SKELETAL COMPLETENESS
123 Mid Male	-		Mainly complete. Fragmentary or missing: ribs, some metacarpal & phalanges (hand/feet), and vertebrae.
126 Mid Unknown	-		Incomplete. Fragmentary or missing: hands, ribs, L arm, and the epiphyses on femurs ,R tibia, and R fibula .
129 Young Female	Knees	11 – Slightly 1 -Moderate	Mainly complete.
155 Mid Male	Hip joints Knees Elbows Shoulders Ankle Wrist	5 – Slightly 1 -Moderate	Mainly complete. Fragmentary or missing: R ulna , feet, and hands .
159 Mid Male	Hips Ankles	6-Slightly 3- Moderately 2-Severely	Incomplete: Fragmentary or missing: ribs, hands, feet, and skull.
185 Mid Male	-	23-Slightly	Mainly complete. Fragmentary or missing: phalanges from hands and feet.
186 Older Male	Ankle Shoulder Elbow	5-Slightly	Mainly complete. Fragmentary or missing: pelvis fragmentary, R humerus, ribs, R ulna and radius, L femur, sternum, scapula, and vertebrae.
210 Older Male	Shoulder	4-Slightly	Mainly complete. Fragmentary or missing: vertebrae.
215 Mid Female	Shoulders Hip Elbows Wrist	5-Slightly 1-Moderately	Mainly complete. Fragmentary or missing: ribs, sternum and feet.
218 Mid Female	Wrist	9-Slightly 2- Moderately	Mainly complete. Fragmentary or missing: Ribs, scapula, lower arm bones and feet .
227 Older Female	-	5-Slightly	Mainly complete.
229 Mid Unknown Sex	Elbows	2-Slightly	Mainly complete. Fragmentary or missing: sternum, ribs, hands and sacrum.
231 Mid Male	-	-	Mainly complete. Fragmentary or missing: vertebrae and hands/feet.

BURIAL	NON-VERTEBRAL JOINTS AFFECTED	NO. VERTEBRAL BODY SURFACES WITH OA (> ½ SURFACE VISIBLE)	SKELETAL COMPLETENESS
237 Mid Female	Shoulder Hip	-	Mainly complete. Fragmentary or missing: rib, scapula, and sacrum.
265 Mid Male		4-Slightly	Mainly complete. Fragmentary or missing: vertebrae and ribs.
319 Older Female	Knee		Mainly complete. Fragmentary or missing: ribs, leg epiphysis, and vertebrae.
323 Older Female	Wrist		Mainly complete. Fragmentary or missing: ribs, scapula, pelvis, feet, patella, sacrum and vertebrae and the long bone epiphysis in poor condition.
325 Young Male	-	-	Incomplete. Fragmentary or missing: vertebrae, ribs, scapula, arms, and pelvis bones.
334 Young Female	Shoulder Elbow Wrist Hip Ankle	2-Slightly 1-Moderately	Mainly complete. Fragmentary or missing: Cranium , feet, sternum, tibia and fibula
360 Mid Unknown	-	-	Mainly complete. Fragmentary or missing: vertebrae.
367 Young Male	Elbows Hip Knees	-	Mainly complete. Fragmentary or missing: feet.
382 Mid Unknown Sex	Elbow Knee Ankle		Mainly complete. Fragmentary or missing: vertebrae and ribs.
383 Mid Female	Knee Foot		Mainly complete. Fragmentary or missing: ribs, scapula, clavicle, vertebrae , and hands.
390 Mid Male	Knee		Mainly complete. Fragmentary or missing: ribs, scapula, vertebrae, and sacrum.
392 Mid Male	Elbows	19-Slightly 5- Moderately	Mainly complete.

BURIAL	NON-VERTEBRAL JOINTS AFFECTED	NO. VERTEBRAL BODY SURFACES WITH OA (> ½ SURFACE VISIBLE)	SKELETAL COMPLETENESS
407 Older Female	Shoulders Elbows Wrists Hips Knees Ankles	2-Slightly 3-Moderately	Mainly complete. Fragmentary or missing: a femur and pelvis.
408 Older Male	Shoulder Wrist	17-Slightly	Mainly complete.
415 Young Unknown Sex	Shoulder Wrist		Mainly complete. Fragmentary or missing: crania, ribs, vertebrae, pelvis and sacrum and feet.
416 Young Female	-	-	Mainly complete. Fragmentary or missing: facial bones, sternum and hand and foot phalanges.
419 Young Female	Elbows Shoulder Wrist Knees		Mainly complete. Fragmentary or missing: facial bones, vertebrae, and scapula.
431 Older Male	Shoulders Hips Wrists Elbows	15-Slightly 4-Moderately	Mainly complete.
433 Mid Female	-	1-Slightly	Mainly complete. Fragmentary or missing: ribs, scapula, pelvis and femurs.
449 Young Female	Shoulders Hips Elbows Knees	32-Slightly 1-Moderately	Mainly complete.
474 Young Female	Hip		Mainly complete. Fragmentary or missing: scapula, ribs, clavicle, and vertebrae.
535 Mid Female	Wrist Elbow Shoulder	1-Slightly	Mainly complete. Fragmentary or missing: femur
539 Mid Male	-	-	Mainly complete. Fragmentary or missing: sternum, and ribs.
549 Mid Male	Shoulder Wrist Hip	2-Slightly	Mainly complete.

BURIAL	NON-VERTEBRAL JOINTS AFFECTED	NO. VERTEBRAL BODY SURFACES WITH OA (> ½ SURFACE VISIBLE)	SKELETAL COMPLETENESS
554 Mid Female	-	18-Slightly 3- Moderately	Mainly complete. Fragmentary or missing: feet.

Table A 20: DJD or joint anomalies identified at Noen U-Loke, taken from Tayles et al. (2007).

BURIAL NO	DESCRIPTION
NUL26 Young male.	No changes or slight marginal osteophytes on most joints, with the exception of the patellae, where in addition to slight marginal lipping there are discrete osteophytes on the articular surfaces, with marked pitting. These are not matched by changes on the distal articulating surfaces of the femora.
NUL27 Mid male.	No changes or slight marginal osteophytes on most appendicular joints. The joints on the vertebrae also have either no changes or slight marginal osteo-phytes.
NUL42 Old male.	No change or slight marginal osteophytes on most appendicular and vertebral joints.
NUL107 Young male.	No change on most appendicular and vertebral joints. Note description of lesions related to infectious disease below.
NUL108 Old female.	Many appendicular joints and vertebral joints with severe marginal osteophytes and pitting of articular surfaces, including hands and feet.

Table A 21: Individuals in Ban Non Wat with potential evidence of an anaemic reaction.

BURIAL	DESCRIPTION	LESION SIZE	ORBIT PRESENCE	CRANIA PRESENCE
185	Healed Porosity only Large portions of the crania are not visible due to concretion.	Frontal 57 x 63 mm	>1/2 No Cribra orbitalia visible	Complete
215	Healed Barely discernible porosity	Frontal 9 x 4mm	<1/2 No Cribra orbitalia visible	Slight damage
323	Healed Porosity only	Left parietal 29.8 x 27.3mm Right parietal 28.3 x 27.3mm	<1/2 No Cribra orbitalia visible	>1/2
367	Healed Porosity only	Parietal bone - 31.7 x 27.3mm Occipital - 16.2 x 20.0mm	<1/2 No Cribra orbitalia visible	<1/2
383	Healed Porosity only Large portions of the crania are not visible due to concretion. May be evidence of an infection and not PH.	Left frontal -33.5 x 22.5 mm Left parietal - 34.8 x 16.6 mm	Missing	>1/2
392	Healed Porosity and cranial thickness Slight thickness at porosity is approx 10mm. Some of the inner table cortex is thin at the coronal suture.	Parietal 87.8 x 67.3 mm	<1/2 No Cribra orbitalia visible	Complete
408	Healed Barely discernible porosity Large portions of the crania are not visible due to concretion.	Left parietal and right occipital 50 x 50 mm	>1/2 No Cribra orbitalia visible	Complete
431	Healed Barely discernible porosity Large portions of the crania are not visible due to concretion.	Right parietal 27 x 27 mm	Slight damage No Cribra orbitalia visible	Complete
439	Healed Porosity only Large portions of the crania are not visible due to concretion.	Frontal 100 x 100 mm	>1/2 No Cribra orbitalia visible	Complete

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Table A 22: Photographs of pitting visible on the crania of individuals at Ban Non Wat.

BURIAL NO	PHOTOGRAPH
185	
323	

BURIAL NO	PHOTOGRAPH
367	
383	

BURIAL NO	PHOTOGRAPH
392	
439	

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Table A 23: Pathological changes found in the skeletons at Noen U-Loke (Tayles et al., 2007).

BURIAL	AGE AND SEX	PATHOLOGICAL LESIONS	DIAGNOSIS
NUL26	Young adult male	Torso Costal cartilages calcified and costo-vertebral articular surfaces porous with marginal osteophytes Large lytic lesions on both surfaces of right sterno-clavicular joint.	Unknown. Differential diagnosis includes hyperthyroidism; Addison's disease, congenital adrenal hyperplasia.
NUL27	Mid age Male	Foot Lytic lesion on metatarsal head, and severe osteophyte. Proximal phalanx has an extensive, sharp osteophyte, suggestive of hyperextension of the joint. The adjacent medial margin of the first distal phalanx has a spicule of bone extending proximally. Vertebral Congenital lumbar vertebrae anomalies. Presence of a sixth lumbar vertebra, possibly spondylolysis and the complete fusion of two lumbar vertebrae. The L3 body is malformed with an anterior height approximately half that of a normal vertebra	Polyarticular porosity and marginal osteophytes on vertebral column and appendicular skeleton suggests widespread but minor joint degeneration of unknown aetiology.
NUL36	Young adult female	Facial Possible lesions on facial bones. Vertebrae Lytic lesions on thoracic and lumbar vertebrae and ankylosis and proliferative periostitis. Spine bows to the left.	Non-specific osteomyelitis or Tuberculoses.
NUL42	Older male	Numerous lesions throughout the body – lytic and deformative. Skull Depression fracture – healed.	Leprosy.
NUL78	Mid age adult ? sex	Leg Left tibia. Remodelled periostitis with porosity and thickened cortex.	Unilaterality, location, and nature suggests a bony response to an overlying soft tissue lesion, probably traumatic.
NUL87	Adult ? sex	Foot Phalanx has discrete porous lesion.	Poor condition precludes diagnosis: most probably traumatic.
NUL94	Older male	Lesions on the clavicles.	Difficult as skeleton is in poor condition.
NUL107	Young adult male	Numerous pathological changes in hands, feet, legs and sternum.	Leprosy.

NUL108	Old adult Female	Vertebral Thoracic body wedge shaped with fractures on superior endplate, no active lesions, other vertebrae normal. Feet Both feet subtalar joint, navicular, intermediate and lateral cuneiform, cuboid, base of 4th metatarsal have severe porosity, joint surface deformity, and marginal osteophytes.	Vertebra: traumatic fracture. Feet: Unknown diagnosis.

Table A 24: Bony anomalies in the Ban Non Wat sample.

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
123 Mid adult Male	Right fibula, anterior proximal shaft	Periosteal surface Woven and sclerotic Lesion not healed completely. 32.6 x 6.3mm - raised irregular surface- no porosity. The left fibula has a fracture in the same location.	
	Left fibula	Callus formation, sclerotic reaction Thickening of width of shaft Posterior side - the affected area has extensive remodelling, the surface is irregular and more pronounced than the anterior. No porosity and healing is complete.	
126 Mid adult, Unknown Sex	Right tibia, proximal shaft	Lateral-small remodelled area.10x5mm, area raised. Medial- large surface area with striations. uneven surface.	
	Right fibula	Large number of small lesions on anterior, posterior and lateral surfaces. Lateral-one area dips slightly& is smooth, this area bulges slightly. Beneath this are a series of lesions heading distally Medially - on posterior border is an uneven line of lesions. Posterior- small thin lesion distal end, healed, next to it is another unhealed lesion.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
129 Young adult Female	Right rib, lower rib at the angle - posterior view, c. 65mm from costal articular facet	Sclerotic reaction. Costal groove is wide with minor spicules along the edge, remodelled area is raised intercostal muscle attachment damage?	
155 Mid adult Male	Left clavicle Mid shaft	Callus formation, sclerotic reaction. Shaft is thick, irregular, shallow groove may be indicative of spiral fracture.	
	Left pelvis ilium,superior to the acetabulum, margin of gluteus minimus.	Bone is striated in one direction. Reactive bone, irregular surface. Ligament trauma?	
	Right pelvis ilium, superior to the acetabulum, margin of gluteus minimus.	Bone is striated in one direction. Reactive bone, porous, irregular surface. Ligament trauma?	
	Left femur	Extensive lesions on shaft. Anterior aspect on proximal, raised, smooth, uneven surface. Distal striations. two- lesion on medial aspect runs the whole length covers most areas around supracondylar lines.	
	Right femur	Extensive lesions on shaft. Anterior aspect on proximal, raised, smooth, uneven surface. Distal striations. two- lesion on medial aspect runs the whole length covers most areas around supracondylar lines.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left ulna	Proximal shaft-porous lesion on lateral aspect, in location of supinator attachment area, and edge of anconeus Trauma ? probably tear. Distal shaft - anterior aspect. woven bone- extensive concretion.	
	Left radius	Bicep attachment posterior aspect has porous and woven lesion.	
	Right radius	Bicep attachment posterior aspect has porous and woven lesion.	
	Right tibia, majority of shaft	Striations and thick reactive bone on all surfaces of shaft. Distal shaft, it is visibly sitting on top of normal bone. Non-striated lesions are porous.	
	Left tibia, majority of shaft	Striations and thick reactive bone on all surfaces of shaft. Distal shaft, it is visibly sitting on top of normal bone. Non-striated lesions are porous.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left fibula	Medial surface- lesions run length, distal half are raised porous, proximal half is series of sclerotic lesions along medial crest - both sides. Lateral surface- various lesions of different form along length.- striations, raised porous, and raised smooth.	
	Right fibula	Medial surface- lesions run length, distal half are raised porous, proximal half is series of sclerotic lesions along medial crest - both sides. Lateral surface- various lesions of different form along length.- striations, raised porous, and raised smooth.	
	Left 5th metatarsal Distal shaft medial-plantar	A layer of porous bone deposited on bone.	
	5th metatarsal Right Dist 1/3 shaft medial-plantar-superior	A layer of porous bone deposited on bone.	
	Right 1st metatarsal Distal shaft superior	A thin layer of porous bone deposited on bone.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
159 Mid adult, Male	Left humerus, distal shaft, posterior surface	Barely visible lesions, bubbly blistered appearance, uneven surface.	
185 Mid adult Male	Left femur, lateral at interface of prox- mid 1/3 shaft.	Sclerotic reaction Dense bone, raised area.	
	Right tibia, posterior, mid shaft, 118mmm above medial malleolus	Surface is smooth and lacks striations. Sclerotic reaction	
	Right fibula, proximal shaft, posterior side	Periosteal or subchondral surface focal bone loss, unifocal 1-5cm, circumscription, sclerotic reaction. Sharp raised edges, as a result groove appears deep. perhaps traumatic ripping to the tibialis posterior .	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left tibia, mid shaft, posterior surface	Callus formation, sclerotic reaction Thickened irregular bone, smooth bone with some porosity. Soleal line is interrupted. At approx. the same area on the fibula, the fibula is thick and robust.	
	Left fibula, Distal shaft, Anterior and medial side	Callus formation, sclerotic reaction Raised irregular area. No apparent difference in bone appearance, but has concretions.	
	Thoracic vertebrae	Schmorl's nodes on t8 to t12	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
186 Older adult Male	Right talus, posterior aspect, lateral tubercle	Diagonal wide cut mark on back of talus, running from the top to the bottom. The sides appear in the process of healing – but may be post-depositional.	
	Left clavicle	Attachment point for costo-clavicular ligament is prominent – diffuse bone loss, with some cortical thinning porous, some sclerotic reaction – ligament damage?	
215 Mid adult Female	Left occipital	Periosteal - Sclerotic reaction, Small lesion, raised deposition of bone, some porosity. Scalp wound?	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left tibia, distal shaft, medial side	Periosteal reaction striations - healing woven bone.	
	Right tibia, distal shaft, medial side	Periosteal reaction, raised remodelling, mainly healed.	
	Left radius, proximal shaft, on tuberosity	Bicep muscle attachment point - enthesophytes on the anterior side of the tuberosity – inflammation of biceps insertion? Strenuous activity?	
	Left fibula	Proximal shaft, flaring on soleus line attachment. External outline altered, flaring metaphyses .	
218 Mid adult, Female	Left femur	Striations cover most of shaft.	
	Right femur	Striations cover most of shaft.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
229 Mid adult Unknown Sex	Left rib	Attachment point for scalenus posterior. Bone remodelling and porosity.area raised slightly. Trauma injury?	
231 Mid adult Male	Right scapula	Suprascapular notch and superior border - the notch is very deep and the border is relatively higher than normal.	
265 Mid adult, Male	Left tibia	The interosseous border is very pronounced. not the same on right tibia and there is no indiction on the left fibula in the same area. Smooth surface.	
	Right 2nd metatarsal, mid shaft.	Anterior - small area of remodelling. pinpoint pitting and irregular – slight.	
325 Young adult, Male	Right 2nd metacarpal, proximal epiphysis	Appears bulky, bulbous and robust. The cortex appears normal and minor remodelling is evident. The left 2nd metacarpal (fragmentary) does not appear malformed.	

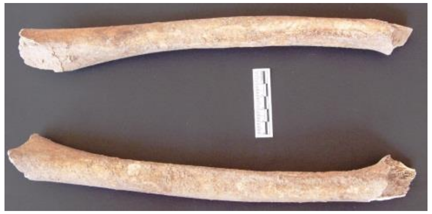
BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left 3rd metacarpal	Distal epiphyseal end. Size of oval foci is approx 6 x 7 mm and depth of approx 3mm. There is remodelling along cortical edge and on trabecular bone.	
	Right patella	Two minor spicules at base where quadriceps tendon attaches.	
	Left patella	Minor spicules at tendon attachment sites, not enthesopathy.	
	Left femur, distal shaft, medial and lateral side	Focal Bone Loss - Cortex, trabeculae or diploe - 2 foci Mixed - <1cm and 1-5cm Boundaries well defined, no sclerosis There are two holes. Concretions on surface and interior - difficult to determine if remodelling has occurred. The first hole is on the front of the femur and measures 21 x 5 mm, the other on the back of the femur is 4 x 6 mm. The holes are in the same location in height - roughly the smaller hole is in the middle of the longer one. The holes suggest a weapon or natural occurrence - such as borer insect or root. There does appear to be some remodelling on the larger hole as there is a smooth round surface visible in a section.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
334 Young adult Female	Left patella, between the tendon attachment points of the quadriceps on anterior surface.	Circumscription, sclerotic reaction. A remodelled groove, some damaged to boundary - possibly where spicules formed from t4he quadriceps tendon.	
360 Mid adult, Unknown sex	Left mandible	Cut mark - On mandibular body, under area from 2nd molar to 1st premolar. Sharp edges, suggesting lack of healing and peri- or post mortem occurrence. It has split further due to pressure on the mandible following burial.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left humerus, distal epiphysis, anterior view	Cut mark - On the boundary of the epiphysis and the shaft. is approximately 36mm in length. There is no remodelling. The cut mark is most likely peri- or post-mortem in origin. The mandible has a similar cut mark and may relate to post-depositional excavation by farmers or grave cutters, Immediately above the cut mark is a septal aperture approximately 5mm in diameter. It is located in the olecranon/coronoid fossa, it appears to be genetic rather than a bone modification. Individual may be a female due to the higher incidence of septal apertures in females.	
367 Young adult Male	Vertebral body	Reactive woven and sclerotic bone, Outer surface - some remodelling.	
382 Mid adult, Unknown sex	Left Patella, lateral side, articular surface - edge of facet for lateral condyle of femur	The edge has marked lipping. Not all of the articular surface has survived. Indication of joint disease.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left tibia, anterior surface of distal epiphysis	Cancellous bone reaction. Cancellous bone expansion making the surface of the epiphysis - non articular surface uneven. There has been extensive post-depositional damage to the area.	
	Left tibia	The soleal line on the left tibia is markedly larger than that of the right tibia.	
383 Mid adult, Female	Left 1st metatarsal, distal epiphysis, dorsal edge	Sclerotic reaction, Lipping on one edge. No spicules. Thickening and remodelling of joint edge.	
392 Mid adult, Male	Left clavicle, proximal shaft of the costo-clavicular ligament attachment	Inferior side of clavicle has bone remodelling. Area is raised and also has a groove between the normal surface and the remodelled area on two sides. Comparisons with the right clavicle show no similarities. possibly a fracture. Cauliflower effect Sclerotic reaction	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Right fibula, proximal shaft, lateral side, extending into the epiphysis	Sclerotic reaction - In addition, the right proximal epiphysis appears considerably larger than the left.	
	Left tibia, distal shaft, medial surface close to epiphysis	Round bulbous growth. By expansive shell type reaction - Sclerotic reaction	 
	Right tibia, distal shaft, lateral surface close to epiphysis	Raised area irregular shape. Sclerotic reaction	
407 Older adult, Female	Left patella, close to the articular surface	Enthesopathy - Remodelled bone with holes and raised areas. Spicules on quadriceps tendon attachment point.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Right patella, close to the articular surface	Enthesopathy - Remodelled bone with holes and raised areas. Spicules on quadriceps tendon attachment point.	
	Left, proximal shaft Femur	Bowed - the angle of the shaft is towards the posterior.	
	Right, proximal shaft femur	Bowed - the angle of the shaft is towards the posterior.	
408 Older adult, Male	Right clavicle, sternal end - upper side, epiphysis	Sclerotic reaction - Reactive remodelling of bone. Left clavicle is normal. costoclavicle ligament damage?	 
415 Young adult, sex unknown	Left radius, distal epiphysis, cortex and cancellous bone on edge of epiphysis	Cortex, trabeculae or diploe - Diffuse bone loss, with associated cortical thinning, Cortical bone loss and the cancellous bone appears have some loss, as structure is spacious.	
419 Young adult, Female	Right distal fibula, medial side	Periosteal sclerotic reaction, Remodelling around what appears to be an enlarged foramen. Diameter of the foramen is now over 2mm. Around the foramen is bone remodelling- it is raised almost 1 mm above the surface of the normal bone shaft.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
431 Older adult, Male	Left parietal bone, near sagittal suture	Cloacae sinus tracks - from medullary Inner table. A number of holes - average 5mm diameter.	
	Right ulna, distal shaft	Callus formation, sclerotic reaction. Bulb shaped. Healed fracture.	
449 Young adult, Female	Right temporal bone	Depressed, outer and inner tables. Blunt, round Non-union There is no remodelling. possibly post-depositional or perimortem.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left femur, proximal epiphysis, lateral side	Depressed, outer table only. Blunt oval. Callus formation, sclerotic reaction. Appears to have some remodelling around one edge but the rest are sharp. Possibly post-depositional.	
474 Young adult, Female	Left hamate -non articular – dorsal surface	Sclerotic reaction, Porous, small and bulbous.	
	Right distal ulna, along the epiphyseal boundary on the ulna	Focal Bone Loss Unifocal. Cortex, trabeculae or diploe <1cm. Margins, not sharply defined The form is a small ditch - may be related to epiphyseal fusion.	 
535 Mid adult, Female	Left ulna, styloid process	The styloid process is unusually formed. Appears that it could either be a healed fracture or the ulna collateral ligament or the meniscus fibrocartilage has been torn, damaging the process, which has remodelled. It appears to curl around and point. The triquetral is not present, but the lunate bone has some evidence of osteophyte formation.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left tibia, medial surface	Lesion - minor raised striations in area approx 8 x 1.5cm. some striations have pinpoint pitting, not very noticeable, healing is not complete, but there is some smoothed healed areas.The right tibia has lesion in same location, but it is more noticeable in the left tibia.	
	Right tibia, medial surface	Lesion - minor raised striations in area approx 8 x 1.5cm. some striations have pinpoint pitting, not very noticeable, healing is not complete, but there is some smoothed healed areas. The left tibia has lesion in same location.	
	Right 2nd metatarsal mid shaft, anterior	Bone is bowed on the anterior surface. Fracture appears well healed.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
539 Mid adult Male	Left clavicle	Two locations - sternal end, towards the anterior side, within a groove. Towards the lateral end on the superior side on the shaft. Areas of porosity - sternal end - large pores - 4x6mm area. Maybe related to traumatic injury to superior surface of clavicle, where is a line of large vascular pores. Probably related to traumatic injury of the deltoid. not quite healed 30 x 4mm. Largest pores are 2mm in diameter.	
	Sternum	The 1st sternebrae. posterior side - porous woven bone on back of sternum fragment. Not found on other sections.	
	Left femur	At third trochanter/gluteal tuberosity - the gluteus maximus muscle attachment point area is quite marked. Possibly from activity.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left pelvis	Lateral surface, adjacent to the acetabulum, superior to the acetabulum. Cartilage- where the ilium-ischium join. Small area of bone remodelling. The area is higher than the surrounding normal bone. Not completely healed. Most likely a traumatic injury relating to fibrous cartilage damage than pathological condition. Remodelling is porous.	
549 Mid adult, Male	Left lateral sternum, anterior side	Sclerotic reaction. Remodelled bone on sternum fragment. May not be pathological.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Frontal bone	Porosity along glabella and above eyes, mainly on right side. Above this area there is a series of small straight lines. Unclear whether this is post-depositional damage.	
	Left 5th metacarpal, medial side, proximal shaft	Sclerotic reaction. Healed, raised lesion is visible dorsally and palmar.	
554 Mid adult, Female	Right radius, mid shaft, along the inter-osseous border.	Sclerotic reaction. Small, raised lesion directly opposite the location of the fracture on the right ulna. May be indicative of a small fracture in this area.	
	Right fibula, middle shaft, lateral view, next to the inter-osseous border.	Sclerotic reaction. Periostitis - healing, remodelling well progressed	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Right tibia, lateral surface, proximal shaft	Sclerotic reaction. Periostitis and a raised healed lesion in the same location.	
	Right distal ulna, frontal view. 11mm beneath area affected by fracture.	Periosteal or subchondral surface Diffuse bone loss, without associated cortical thinning Reactive woven bone. Small area of periostitis- healing but still has sharp ridges and valleys.	
	Right ulna, mid shaft, all aspects	Callus formation, sclerotic reaction Healed fracture. Shaft is wider than normal, the bone is smooth with some pitting around an indentation. Beneath the healed area there is an area of periostitis on anterior. Unclear whether or not the healed fracture caused angulation of the bone due to the damage to the area.	
	Right 3rd metatarsal, mid shaft	Callus formation, sclerotic reaction. Mid shaft is bulbous with some additional lesions.	
	Right 4th metatarsal	Bowed, the distal end of the shaft bows markedly laterally. The 4th metatarsal on left foot exhibits same.	
	Right, 5th metatarsal	Bowed - the distal end of the shaft bows markedly laterally. The 5th metatarsal on left foot exhibits same.	

BURIAL	LOCATION ON SKELETON	DESCRIPTION OF ANOMALY	
	Left 5th metatarsal	Bowed - the distal end of the shaft bows markedly laterally. The 5th metatarsal on right foot exhibits same.	
	Left 4th metatarsal	Bowed, the distal end of the shaft bows markedly laterally. The 4th metatarsal on right foot exhibits same.	

Table A 25: Summary of conditions in the sample from Ban Non Wat.

BURIAL	SEX AGE	PHASE	TEETH	POROTIC HYPEROSTOSIS	PATHOLOGICAL CONDITIONS	DJD
123	Male mid	Late Bronze	Moderate to severe tooth wear		Trauma. Infection at both similar locations on the fibula, but one of which has caused a fracture.	-
126	Unknown adult	Late Bronze	Moderate tooth wear		Soft tissue infection, trauma or skin ulcers.	-
129	Female young-mid	Late Bronze	Severe tooth wear		Muscle attachment damage – trauma or activity?	Knees Slight OA Vertebrae
155	Male Mid adult	Mid Bronze	Severe tooth wear, periodontal disease		Possible fracture of clavicle. Trauma to ligament attachments in pelvis, severe periodtitis on legs, muscle attachment lesions on arms. Stressful activities and trauma to bone. Extensive soft tissue infection, trauma or skin ulcers in legs.	Hip joints Knees Elbows Shoulders Ankle Wrist Slight OA Vertebrae
159	Male mid adult	Mid Bronze	-		Minor soft tissue infection or trauma.	Hips Ankles Moderate OA Vertebrae
185	Male mid adult	Late Bronze	Moderate to severe tooth wear	Slight	Possibly soft tissue injection, trauma skin ulcers on legs, and Schmorl's nodes indicate strenuous activity.	Slight OA Vertebrae
186	Male Older adult	Late Bronze	Severe tooth wear, periapical cavities,		Cut mark may be post-depositional. Rhomboid fossa. Indicative of manual labour.	Ankle Shoulder Elbow Slight OA Vertebrae
210	Male Older adult	Mid Bronze	Severe tooth wear, periodontal disease			Shoulder Slight OA Vertebrae
215	Female adult	Late Bronze	Moderate to severe tooth wear, periodontal disease	Slight	Scalp wound? Legs – soft tissue infection, trauma or skin ulcers. Arms - inflammation of biceps insertion? Strenuous activity?	Shoulders Hip Elbows

BURIAL	SEX AGE	PHASE	TEETH	POROTIC HYPEROSTOSIS	PATHOLOGICAL CONDITIONS	DJD
					Legs – strenuous activity, trauma.	Wrist Slight OA Vertebrae
218	Female mid adult	Late Bronze	Moderate to severe tooth wear		Soft tissue infection, skin ulcers, trauma.	Wrist Slight OA Vertebrae
227	Female older adult	Late Bronze	Severe tooth wear, infrabony pocket			Slight OA Vertebrae
229	Unknown adult	Early Iron	Light tooth wear		. Trauma injury?	Elbows Slight OA Vertebrae
231	Male mid adult	Early Iron	Moderate tooth wear		Normal – Congenitial.	-
237	Female adult	Early Iron	Moderate to severe tooth wear, periodontal disease, periapical cavities			Shoulder Hip
265	Male mid adult	Late Bronze	Light tooth wear		Leg – trauma- activity. Foot – Trauma.	Slight OA Vertebrae
319	Female Adult older	Early Iron	Moderate to severe tooth wear, periodontal disease			Knee
323	Female Adult older	Early Iron	Severe tooth wear	Slight		Wrist
325	Male young adult?	Early Iron	Moderate to severe tooth wear		Hands – trauma. Knee – trauma – activity. Femur -. The holes suggest a weapon or natural occurrence - such as borer insect or root.	-
334	Female Adult	Early Iron	Moderate tooth wear, periodontal disease		Activity, trauma.	Shoulder Elbow

BURI AL	SEX AGE	PHASE	TEETH	POROTIC HYPEROSTOSIS	PATHOLOGICAL CONDITIONS	DJD
	young					Wrist Hip Ankle Slight OA Vertebrae
360	Unknown Mid adult	Early Iron	Moderate to severe tooth wear		Peri- or post mortem occurrence – cut mark.	-
367	Male adult young	Early Iron	Severe tooth wear	Slight	Soft tissue infection, trauma or skin ulcer.	Elbows Hip Knees
382	Unknown adult	Early Iron	-		Soft tissue infection, activity, trauma or skin ulcer.	Elbow Knee Ankle
383	Female adult	Early Iron	Severe tooth wear	Slight		Knee Foot
390	Male adult	Early Iron	Moderate to severe tooth wear, periodontal disease			Knee
392	Male adult	Mid Bronze	Moderate tooth wear	Slight	Clavicle: Rhomboid fossa. Indicative of manual labour. Trauma. Lower legs: Trauma, infection. Tibia: possible osteoid osteoma.	Elbows Slight to Moderate OA Vertebrae
407	Female adult older	Mid Bronze	Severe tooth wear, periapical cavities		Knee –Activity, trauma. Femur – congenital.	Shoulders Elbows Wrists Hips Knees Ankles Slight to Moderate OA Vertebrae

BURIAL	SEX AGE	PHASE	TEETH	POROTIC HYPEROSTOSIS	PATHOLOGICAL CONDITIONS	DJD
408	Male old adult	Mid Bronze	Severe tooth wear, periodontal disease, periapical cavities,	Slight	Clavicle: Rhomboid fossa. Indicative of manual labour. Trauma?	Shoulder Wrist Slight OA Vertebrae
415	Unknown young adult	Early Iron	Light tooth wear		Infection, trauma.	Shoulder Wrist
416	Female young adult	Mid Bronze	Moderate tooth wear			-
419	Female young adult	Early Iron	Light tooth wear		Infection, trauma.	Elbows Shoulder Wrist Knees
431	Male adult older	Mid Bronze	Severe tooth wear, infrabony pocket	Slight	Skull – post depositional damage? Arm – Trauma/fracture.	Shoulders Hips Wrists Elbows Slight to Moderate OA Vertebrae
433	Female mid adult	Early Iron	Light to moderate tooth wear			Slight OA Vertebrae
449	Female young adult	Mid Bronze	Moderate to severe tooth wear		Trauma.	Shoulders Hips Elbows Knees Slight OA Vertebrae
474	Female adult young	Early Iron	Light tooth wear, periapical cavities,		Infection, trauma.	Hip
535	Female	Mid	Moderate to severe		Trauma, infection, fracture to ulna?	Wrist

BURI AL	SEX AGE	PHASE	TEETH	POROTIC HYPEROSTOSIS	PATHOLOGICAL CONDITIONS	DJD
	mid adult	Bronze	tooth wear, infrabony pocket			Elbow Shoulder Slight OA Vertebrae
539	Male mid adult	Mid Bronze	Moderate tooth wear		Trauma, activity.	-
549	Male mid adult	Mid Bronze	Moderate to severe tooth wear, infrabony pocket, periapical cavities,		Trauma, infection.	Shoulder Wrist Hip Slight OA Vertebrae
554	Female adult mid	Mid Bronze	Moderate tooth wear		Trauma, infection, fractured ulna.	Slight to Moderate OA Vertebrae

Appendix B SEAHI

Table A 26: SEAHI Scores of individual attributes and overall SEAHI Scores - BNW and NUL

BURIAL NO	AGE	SEX	CHILDHOOD LESIONS	DJD	TRAUMA	DENTAL	EH	PATHOLOGY	LONG BONE LENGTH	AGE SCORE	NO OF ATTRIBUTES	SEAHI SCORE
NUL36	Young adult	Female	100	85.80	100	72.50	0	0.00	81.25	0	8	38.56
NUL26	Young adult	Male	100	56.80	100	71.43	0	0.00	81.82	0	8	40.36
NUL107	Young adult	Male	100	100.00	80	100.00	100	0.00	67.50	0	8	42.59
BNW155	Mid adult	Male	100	49.98	80	87.50	100	14.29	100.00	50	8	42.63
NUL108	Older adult	Female	100	42.90	80	36.29	100	100.00	90.63	100	8	43.02
NUL42	Older adult	Male	100	58.58	80	85.58	100	0.00	100.00	100	8	44.35
BNW218	Mid adult	Female	100	85.68	100	94.64	0	14.29	75.00	50	8	44.67
NUL27	Mid adult	Male	100	63.90	80	84.48	100	85.71	77.08	50	8	44.90
NUL78	Mid adult	Unknown	100	92.90	80	100.00	100	14.29		50	7	45.13
BNW535	Mid adult	Female	100	67.12	80	87.50	100	85.71	75.00	50	8	45.23
BNW549	Mid adult	Male	100	71.40	100	63.89	50	85.71	75.00	50	8	46.06
BNW215	Mid adult	Female	100	64.26	100	81.50	0	71.43	96.43	50	8	46.31
BNW325	Young adult	Male	100	92.82	100	94.23	100	100.00	25.00	0	8	46.49
BNW407	Older adult	Female	100	57.12	100	43.97	100	85.71		100	7	47.09
BNW334	Young adult	Female	100	64.26	100	87.50	100	85.71	75.00	0	8	47.17
BNW159	Mid	Male	100	77.11	100	75.00	100	57.14	75.00	50	8	47.77

BURIAL NO	AGE	SEX	CHILDHOOD LESIONS	DJD	TRAUMA	DENTAL	EH	PATHOLOGY	LONG BONE LENGTH	AGE SCORE	NO OF ATTRIBUTES	SEAHI SCORE
	adult											
BNW123	Mid adult	Male	100	99.96	90	97.41	0	71.43	87.50	50	8	47.80
BNW186	Older adult	Male	100	71.40	100	65.32	50	85.71	75.00	100	8	47.97
BNW554	Mid adult	Female	100	92.82	80	97.50	100	85.71	75.00	50	8	48.18
NUL40	Young adult	Female	100	100.00	100	97.32	0	100.00	75.00	0	8	48.24
BNW210	Older adult	Male	100	85.68	100	53.41	0	100.00	87.50	100	8	48.30
NUL113	Young adult	Female	100	100.00	100	72.22	0	100.00	100.00	0	8	48.44
BNW392	Mid adult	Male	100	85.68	100	92.97	50	57.14	78.13	50	8	48.47
NUL73	Mid adult	Unknown	100		100	65.00	50	100.00		50	6	48.48
BNW367	Young adult	Male	100	75.68	100	94.64	100	71.43		0	7	48.50
NUL44	Young adult	Male	100	100.00	100	97.66	0	100.00	79.17	0	8	48.62
BNW237	Mid adult	Female	100	71.40	100	61.36	100	100.00		50	7	48.71
NUL4	Young adult	Unknown	100	100.00	100	100.00	0	100.00		0	7	48.97
BNW408	Older adult	Male	100	78.54	100	64.66	50	85.71	81.25	100	8	49.06
BNW474	Young adult	Female	100	91.67	100	70.31	100	85.71	87.50	0	8	49.23
BNW229	Mid adult	Unknown	100	84.25	90	87.90	100	85.71		50	7	49.26
BNW419	Young adult	Female	100	71.40	100	100.00	100	85.71		0	7	49.31
BNW449	Young adult	Female	100	67.12	100	97.50	100	100.00	82.50	0	8	49.48
BNW431	Older adult	Male	100	64.26	90	82.81	100	100.00	81.25	100	8	49.61
NUL50	Young	Male	100	100.00	100	87.50	0	100.00	100.00	0	8	49.62

BURIAL NO	AGE	SEX	CHILDHOOD LESIONS	DJD	TRAUMA	DENTAL	EH	PATHOLOGY	LONG BONE LENGTH	AGE SCORE	NO OF ATTRIBUTES	SEAHI SCORE
	adult											
BNW416	Young adult	Female	100	92.82	100	80.00	100	100.00	75.00	0	8	49.67
NUL110	Mid adult	Female	100		100	63.00	100	100.00	75.00	50	7	49.69
NUL94	Older adult	Male	100	85.70	100	69.00	0	85.71	100.00	100	8	49.92
BNW129	Young adult	Female	100	85.68	100	80.00	100	85.71	93.75	0	8	50.01
NUL52	Older adult	Female	100	100.00	100	23.08	100	100.00		100	7	50.15
NUL30	Young adult	Female	100		100	80.77	100	100.00	85.00	0	7	50.19
NUL61	Young adult	Male	100	100.00	100	100.00	100	100.00	58.33	0	8	50.39
BNW390	Mid adult	Male	100	91.67	100	66.81	100	85.71	83.33	50	8	50.40
NUL62	Mid adult	Female	100	100.00	100	86.67	100	100.00	50.00	50	8	50.45
NUL104	Young adult	Female	100	100.00	100	100.00	50	100.00		0	7	50.90
NUL35	Mid adult	Female	100	100.00	100	79.00	100	100.00	62.50	50	8	50.92
BNW415	Young adult	Unknown	100	75.00	100	97.58	100	85.71	100.00	0	8	51.00
NUL37	Older adult	Female	100	75.74	100	79.17	100	100.00	70.00	100	8	51.32
BNW185	Mid adult	Male	100	92.82	90	85.94	100	85.71	100.00	50	8	51.41
NUL5	Young adult	Male	100	100.00	100	100.00	50	100.00	91.67	0	8	51.56
NUL111	Young adult	Male	100	100.00	100	94.74	100	85.71		0	7	51.61
NUL98	Older adult	Male	100	100.00	100	65.00	100	100.00	62.50	100	8	51.64
BNW382	Mid adult	Unknown	100	91.39	100	100.00	100	57.14		50	7	51.79
NUL39	Young	Male	100	100.00	100	93.75	50	100.00	100.00	0	8	51.79

BURIAL NO	AGE	SEX	CHILDHOOD LESIONS	DJD	TRAUMA	DENTAL	EH	PATHOLOGY	LONG BONE LENGTH	AGE SCORE	NO OF ATTRIBUTES	SEAHI SCORE
	adult											
NUL60	Young adult	Male	100	100.00	100	100.00	100	100.00	75.00	0	8	51.82
NUL1	Mid adult	Male	100	100.00	100	100.00	50	100.00	75.00	50	8	51.93
BNW383	Mid adult	Female	100	87.50	100	90.32	100	85.71		50	7	52.07
NUL69	Young adult	Male	100	100.00	100	94.23	100	100.00	83.33	0	8	52.08
NUL74	Young adult	Male	100	100.00	100	97.50	50	100.00	100.00	0	8	52.08
NUL76	Mid adult	Unknown	100		100	100.00	50	100.00		50	6	52.08
BNW265	Mid adult	Male	100	92.82	100	97.12	100	57.14	91.67	50	8	52.24
NUL67	Young adult	Unknown	100	100.00	100	94.00	100	100.00		0	7	52.30
NUL75	Young adult	Unknown	100	100.00	100	94.23	100	100.00		0	7	52.32
BNW539	Mid adult	Male	100	92.82	90	100.00	100	85.71	100.00	50	8	52.50
NUL59	Young adult	Unknown	100	100.00	100	96.43	100	100.00		0	7	52.51
BNW126	Mid adult	Unknown	100	100.00	100	100.00	100	57.14		50	7	52.63
NUL10	Older adult	Female	100		100	68.75	50	100.00	100.00	100	7	52.77
NUL33	Young adult	Male	100		100	91.00	100	100.00	81.25	0	7	50.72
NUL14	Mid adult	Male	100	100.00	100	92.86	100	100.00	75.00	50	8	53.06
BNW323	Older adult	Female	100	92.82	100	65.91	100	100.00		100	7	53.23
BNW319	Older adult	Female	100	85.68	100	74.46	100	100.00		100	7	53.30
BNW231	Mid adult	Male	100	92.82	100	92.74	100	100.00		50	7	53.55
NUL66	Mid	Male	100	100.00	100	100.00	100	100.00	75.00	50	8	53.62

BURIAL NO	AGE	SEX	CHILDHOOD LESIONS	DJD	TRAUMA	DENTAL	EH	PATHOLOGY	LONG BONE LENGTH	AGE SCORE	NO OF ATTRIBUTES	SEAHI SCORE
	adult											
NUL82	Mid adult	Female	100	100.00	100	85.71	100	100.00		50	7	53.62
NUL96	Mid adult	Unknown	100	100.00	100		100	100.00		50	6	54.13
BNW433	Mid adult	Female	100	92.82	100	100.00	100	100.00	91.67	50	8	54.43
BNW360	Mid adult	Unknown	100	99.96	100	100.00	100	100.00		50	7	54.88
NUL99	Older adult	Female	100	100.00	100	76.56	100	100.00	90.00	100	8	54.89
BNW227	Older adult	Female	100	92.82	100	80.68	100	100.00	100.00	100	8	55.45
NUL49	Mid adult	Female	100	100.00	100	100.00	100	100.00	100.00	50	8	55.75
NUL12	Older adult	Female	100	100.00	100	97.50	100	100.00		100	7	56.72

Appendix C Skeletal Data – Correlations

Table A 27: Spearman's rank-order correlation for health index variables and sex, age, location and phase for Ban Non Wat and Noen U-Loke.

			Site	Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
Spearman's rho	**Site**	Correlation Coefficient	1.000	.770**	-.185	.013	.611**	.107	.097	-.174	.452**	-.075
		Sig. (2-tailed)	.	.000	.098	.911	.000	.342	.390	.121	.000	.581
		N	81	81	81	81	75	81	80	81	81	56
	Phase	Correlation Coefficient	.770**	1.000	-.201	.195	.650**	.296**	.217	-.015	.495**	-.062
		Sig. (2-tailed)	.000	.	.072	.082	.000	.007	.053	.892	.000	.651
		N	81	81	81	81	75	81	80	81	81	56
	Age	Correlation Coefficient	-.185	-.201	1.000	-.008	-.287*	-.197	-.451**	.106	-.016	.046
		Sig. (2-tailed)	.098	.072	.	.943	.013	.079	.000	.347	.888	.739
		N	81	81	81	81	75	81	80	81	81	56
	Sex	Correlation Coefficient	.013	.195	-.008	1.000	.065	.123	.075	.169	.130	.033
		Sig. (2-tailed)	.911	.082	.943	.	.579	.275	.507	.132	.248	.810
		N	81	81	81	81	75	81	80	81	81	56
	Joint Disease	Correlation Coefficient	.611**	.650**	-.287*	.065	1.000	.310**	.440**	-.045	.531**	-.119
		Sig. (2-tailed)	.000	.000	.013	.579	.	.007	.000	.702	.000	.402
		N	75	75	75	75	75	75	74	75	75	52
	Trauma	Correlation Coefficient	.107	.296**	-.197	.123	.310**	1.000	-.071	-.204	.386**	-.103
		Sig. (2-tailed)	.342	.007	.079	.275	.007	.	.533	.068	.000	.450
		N	81	81	81	81	75	81	80	81	81	56
	Dental	Correlation Coefficient	.097	.217	-.451**	.075	.440**	-.071	1.000	.061	-.007	-.018
		Sig. (2-tailed)	.390	.053	.000	.507	.000	.533	.	.590	.952	.896
		N	80	80	80	80	74	80	80	80	80	56

		Site	Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
EH	Correlation Coefficient	-.174	-.015	.106	.169	-.045	-.204	.061	1.000	.048	-.202
	Sig. (2-tailed)	.121	.892	.347	.132	.702	.068	.590	.	.673	.135
	N	81	81	81	81	75	81	80	81	81	56
Pathology	Correlation Coefficient	.452**	.495**	-.016	.130	.531**	.386**	-.007	.048	1.000	-.089
	Sig. (2-tailed)	.000	.000	.888	.248	.000	.000	.952	.673	.	.516
	N	81	81	81	81	75	81	80	81	81	56
Long Bone Length	Correlation Coefficient	-.075	-.062	.046	.033	-.119	-.103	-.018	-.202	-.089	1.000
	Sig. (2-tailed)	.581	.651	.739	.810	.402	.450	.896	.135	.516	.
	N	56	56	56	56	52	56	56	56	56	56

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A 28: Ban Non Wat - Spearman's rank-order correlation for health index variables and sex, age, location and phase.

			Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
Spearman's rho	**Phase**	Correlation Coefficient	1.000	-.271	.382*	.240	.364*	.217	.336*	.186	.173
		Sig. (2-tailed)	.	.099	.018	.146	.025	.192	.039	.264	.397
		N	38	38	38	38	38	38	38	38	26
	Age	Correlation Coefficient	-.271	1.000	-.195	.001	-.113	-.435**	-.299	.141	.084
		Sig. (2-tailed)	.099	.	.241	.993	.500	.006	.068	.399	.683
		N	38	38	38	38	38	38	38	38	26
	Sex	Correlation Coefficient	.382*	-.195	1.000	.053	.162	.295	.330*	.103	.070
		Sig. (2-tailed)	.018	.241	.	.754	.331	.073	.043	.540	.734
		N	38	38	38	38	38	38	38	38	26
	Joint Disease	Correlation Coefficient	.240	.001	.053	1.000	.028	.365*	.129	.144	.134
		Sig. (2-tailed)	.146	.993	.754	.	.866	.024	.440	.388	.514
		N	38	38	38	38	38	38	38	38	26
	Trauma	Correlation Coefficient	.364*	-.113	.162	.028	1.000	-.180	-.104	.143	-.148
		Sig. (2-tailed)	.025	.500	.331	.866	.	.280	.534	.392	.472
		N	38	38	38	38	38	38	38	38	26
	Dental	Correlation Coefficient	.217	-.435**	.295	.365*	-.180	1.000	.240	-.232	.200
		Sig. (2-tailed)	.192	.006	.073	.024	.280	.	.147	.162	.327
		N	38	38	38	38	38	38	38	38	26
	EH	Correlation Coefficient	.336*	-.299	.330*	.129	-.104	.240	1.000	.275	.145
		Sig. (2-tailed)	.039	.068	.043	.440	.534	.147	.	.095	.480
		N	38	38	38	38	38	38	38	38	26
	Pathology	Correlation Coefficient	.186	.141	.103	.144	.143	-.232	.275	1.000	-.064
		Sig. (2-tailed)	.264	.399	.540	.388	.392	.162	.095	.	.757
		N	38	38	38	38	38	38	38	38	26

		Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
Long Bone Length	Correlation Coefficient	.173	.084	.070	.134	-.148	.200	.145	-.064	1.000
	Sig. (2-tailed)	.397	.683	.734	.514	.472	.327	.480	.757	.
	N	26	26	26	26	26	26	26	26	26

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A 29: Noen U-Loke - Spearman's rank-order correlation for health index variables and sex, age, location and phase.

			Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
Spearman's rho	**Phase**	Correlation Coefficient	1.000	.055	.218	.435**	.321*	.241	.077	.280	-.098
		Sig. (2-tailed)	.	.727	.160	.007	.036	.124	.625	.069	.608
		N	43	43	43	37	43	42	43	43	30
	Age	Correlation Coefficient	.055	1.000	.134	-.350*	-.222	-.447**	.322*	.005	-.037
		Sig. (2-tailed)	.727	.	.391	.034	.152	.003	.035	.973	.848
		N	43	43	43	37	43	42	43	43	30
	Sex	Correlation Coefficient	.218	.134	1.000	.059	.082	-.096	.074	.249	-.012
		Sig. (2-tailed)	.160	.391	.	.730	.601	.543	.636	.108	.950
		N	43	43	43	37	43	42	43	43	30
	Joint Disease	Correlation Coefficient	.435**	-.350*	.059	1.000	.576**	.456**	.067	.651**	-.202
		Sig. (2-tailed)	.007	.034	.730	.	.000	.005	.694	.000	.323
		N	37	37	37	37	37	36	37	37	26
	Trauma	Correlation Coefficient	.321*	-.222	.082	.576**	1.000	.003	-.272	.578**	-.040
		Sig. (2-tailed)	.036	.152	.601	.000	.	.985	.078	.000	.833
		N	43	43	43	37	43	42	43	43	30
	Dental	Correlation Coefficient	.241	-.447**	-.096	.456**	.003	1.000	-.013	.079	-.158
		Sig. (2-tailed)	.124	.003	.543	.005	.985	.	.933	.617	.404
		N	42	42	42	36	42	42	42	42	30
	EH	Correlation Coefficient	.077	.322*	.074	.067	-.272	-.013	1.000	.079	-.442*
		Sig. (2-tailed)	.625	.035	.636	.694	.078	.933	.	.612	.015
		N	43	43	43	37	43	42	43	43	30
	Pathology	Correlation Coefficient	.280	.005	.249	.651**	.578**	.079	.079	1.000	-.092
		Sig. (2-tailed)	.069	.973	.108	.000	.000	.617	.612	.	.628
		N	43	43	43	37	43	42	43	43	30

		Phase	Age	Sex	Joint Disease	Trauma	Dental	EH	Pathology	Long Bone Length
Long Bone Length	Correlation Coefficient	-.098	-.037	-.012	-.202	-.040	-.158	-.442*	-.092	1.000
	Sig. (2-tailed)	.608	.848	.950	.323	.833	.404	.015	.628	.
	N	30	30	30	26	30	30	30	30	30

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

Appendix D Burial Treatment – Correlation

Table A 30: Correlations between burial treatments at Ban Non Wat and Noen U-Loke.

		Phase	Ornament	Animal	Blade	Pottery	Industry	Other	No. Artefacts	No. Types	No. Ornament	Wild Animal	Exotic Ornament	Ornamental Pottery	Orientation	Site	Age
Phase	Correlation Coefficient	1.000	.230*	-.339**	.454**	-.220*	-.140	-.367**	.061	-.147	.440**	-.018	.412**	.056	.226*	.770**	-.201
	Sig. (2-tailed)	.	.039	.002	.000	.048	.211	.001	.586	.191	.000	.873	.000	.620	.042	.000	.072
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Ornament	Correlation Coefficient	.230*	1.000	-.249*	.168	-.082	-.005	-.066	.242*	.213	.804**	.103	.309**	.610**	-.072	.474**	.077
	Sig. (2-tailed)	.039	.	.025	.134	.465	.967	.559	.030	.056	.000	.359	.005	.000	.524	.000	.494
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Animal	Correlation Coefficient	-.339**	-.249*	1.000	-.110	.220*	.110	.270*	.114	.457**	-.339**	.213	-.157	-.083	.071	-.330**	.139
	Sig. (2-tailed)	.002	.025	.	.330	.048	.329	.015	.310	.000	.002	.056	.161	.462	.527	.003	.216
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Blade	Correlation Coefficient	.454**	.168	-.110	1.000	.244*	.021	.016	.466**	.414**	.318**	.100	.336**	.297**	.079	.287**	.011
	Sig. (2-tailed)	.000	.134	.330	.	.028	.853	.885	.000	.000	.004	.376	.002	.007	.485	.009	.924
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Pottery	Correlation Coefficient	-.220*	-.082	.220*	.244*	1.000	.197	.244*	.538**	.621**	-.029	.106	-.163	.628**	-.019	-.360**	.265*
	Sig. (2-tailed)	.048	.465	.048	.028	.	.078	.028	.000	.000	.797	.345	.146	.000	.863	.001	.017
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Industry	Correlation Coefficient	-.140	-.005	.110	.021	.197	1.000	.274*	.343**	.531**	-.012	.093	-.052	.093	.145	-.150	.288**
	Sig. (2-tailed)	.211	.967	.329	.853	.078	.	.013	.002	.000	.912	.407	.646	.410	.196	.181	.009
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81

		Phase	Ornament	Animal	Blade	Pottery	Industry	Other	No. Artefacts	No. Types	No. Ornament	Wild Animal	Exotic Ornament	Ornamental Pottery	Orientation	Site	Age
Other	Correlation Coefficient	-.367**	-.066	.270*	.016	.244*	.274*	1.000	.326**	.624**	-.020	.125	-.213	.028	.050	-.282*	.079
	Sig. (2-tailed)	.001	.559	.015	.885	.028	.013	.	.003	.000	.860	.265	.056	.806	.656	.011	.481
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
No. Artefacts	Correlation Coefficient	.061	.242*	.114	.466**	.538**	.343**	.326**	1.000	.681**	.517**	.153	.275*	.483**	.013	.005	.302**
	Sig. (2-tailed)	.586	.030	.310	.000	.000	.002	.003	.	.000	.000	.172	.013	.000	.906	.966	.006
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
No. Types	Correlation Coefficient	-.147	.213	.457**	.414**	.621**	.531**	.624**	.681**	1.000	.212	.220*	-.004	.533**	.064	-.158	.289**
	Sig. (2-tailed)	.191	.056	.000	.000	.000	.000	.000	.000	.	.058	.048	.970	.000	.569	.158	.009
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
No. Ornaments	Correlation Coefficient	.440**	.804**	-.339**	.318**	-.029	-.012	-.020	.517**	.212	1.000	.036	.522**	.525**	-.019	.584**	.109
	Sig. (2-tailed)	.000	.000	.002	.004	.797	.912	.860	.000	.058	.	.748	.000	.000	.869	.000	.332
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Wild Animal	Correlation Coefficient	-.018	.103	.213	.100	.106	.093	.125	.153	.220*	.036	1.000	-.076	.169	-.034	.150	-.069
	Sig. (2-tailed)	.873	.359	.056	.376	.345	.407	.265	.172	.048	.748	.	.501	.131	.761	.183	.538
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Exotic Ornament	Correlation Coefficient	.412**	.309**	-.157	.336**	-.163	-.052	-.213	.275*	-.004	.522**	-.076	1.000	.061	-.147	.448**	-.036
	Sig. (2-tailed)	.000	.005	.161	.002	.146	.646	.056	.013	.970	.000	.501	.	.587	.190	.000	.751
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Ornamental Pottery	Correlation Coefficient	.056	.610**	-.083	.297**	.628**	.093	.028	.483**	.533**	.525**	.169	.061	1.000	-.110	.091	.178
	Sig. (2-tailed)	.620	.000	.462	.007	.000	.410	.806	.000	.000	.000	.131	.587	.	.328	.421	.112
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81

		Phase	Ornament	Animal	Blade	Pottery	Industry	Other	No. Artefacts	No. Types	No. Ornament	Wild Animal	Exotic Ornament	Ornamental Pottery	Orientation	Site	Age
Orientation	Correlation Coefficient	.226*	-.072	.071	.079	-.019	.145	.050	.013	.064	-.019	-.034	-.147	-.110	1.000	.079	-.003
	Sig. (2-tailed)	.042	.524	.527	.485	.863	.196	.656	.906	.569	.869	.761	.190	.328	.	.485	.982
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Site	Correlation Coefficient	.770**	.474**	-.330**	.287**	-.360**	-.150	-.282*	.005	-.158	.584**	.150	.448**	.091	.079	1.000	-.185
	Sig. (2-tailed)	.000	.000	.003	.009	.001	.181	.011	.966	.158	.000	.183	.000	.421	.485	.	.098
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Age	Correlation Coefficient	-.201	.077	.139	.011	.265*	.288**	.079	.302**	.289**	.109	-.069	-.036	.178	-.003	-.185	1.000
	Sig. (2-tailed)	.072	.494	.216	.924	.017	.009	.481	.006	.009	.332	.538	.751	.112	.982	.098	.
	N	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81

Appendix E Data

Table A 31: Data from Ban Non Wat and Noen U-Loke: Health and Burial Goods.

Burial No.	Age[16]	Sex[17]	Childhood Lesions Score	Joint Disease Score	Trauma Score	Dental Score	EH Score	Pathology Score	Long Bone Length Score	Age Score	No. Attributes	ZScore	Phase	Ornament Presence[18]	Animal Presence	Blade Presence	Pottery Presence	Industry Presence	Other Presence	No. Goods	No. Types	No. Ornaments	Wild Animal Presence	Special Ornament Presence	Orientation	No. Variables
BNW123	2	1	100	99.96	90	97.41	0	71.43	87.50	50	8	47.80	2	1.00	1.00	0.00	1.00	0.00	1.00	17.00	4.00	2.00	0.00	0.00	1.00	4.00
BNW126	2	3	100	100.00	100	100.00	100	57.14		50	7	52.63	2	1.00	0.00	0.00	1.00	1.00	1.00	11.00	4.00	1.00	0.00	0.00	1.00	4.00
BNW129	1	2	100	85.68	100	80.00	100	85.71	93.75	0	8	50.01	2	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00
BNW155	2	1	100	49.98	80	87.50	100	14.29	100.00	50	8	42.63	1	1.00	1.00	0.00	1.00	1.00	1.00	13.00	5.00	2.00	0.00	0.00	1.00	5.00
BNW159	2	1	100	77.11	100	75.00	100	57.14	75.00	50	8	47.77	1	1.00	1.00	0.00	1.00	0.00	1.00	10.00	4.00	2.00	0.00	0.00	1.00	4.00
BNW185	2	1	100	92.82	90	85.94	100	85.71	100.00	50	8	51.41	2	1.00	1.00	0.00	1.00	0.00	1.00	23.00	4.00	5.00	0.00	0.00	1.00	4.00
BNW186	3	1	100	71.40	100	65.32	50	85.71	75.00	100	8	47.97	2	0.00	0.00	0.00	1.00	0.00	1.00	12.00	2.00	0.00	0.00	0.00	1.00	2.00
BNW210	3	1	100	85.68	100	53.41	0	100.00	87.50	100	8	48.30	1	1.00	0.00	0.00	1.00	1.00	1.00	15.00	4.00	6.00	0.00	0.00	3.00	4.00
BNW215	2	2	100	64.26	100	81.50	0	71.43	96.43	50	8	46.31	2	1.00	1.00	1.00	1.00	1.00	1.00	23.00	6.00	1.00	0.00	0.00	3.00	6.00
BNW218	2	2	100	85.68	100	94.64	0	14.29	75.00	50	8	44.67	2	1.00	0.00	0.00	1.00	1.00	1.00	7.00	4.00	3.00	0.00	0.00	3.00	4.00
BNW227	3	2	100	92.82	100	80.68	100	100.00	100.00	100	8	55.45	2	0.00	0.00	0.00	1.00	1.00	1.00	8.00	3.00	0.00	0.00	0.00	3.00	3.00
BNW229	2	3	100	84.25	90	87.90	100	85.71		50	7	49.26	3	0.00	1.00	0.00	1.00	1.00	1.00	16.00	4.00	0.00	0.00	0.00	1.00	4.00
BNW231	2	1	100	92.82	100	92.74	100	100.00		50	7	53.55	3	1.00	1.00	0.00	1.00	1.00	0.00	10.00	4.00	1.00	0.00	0.00	4.00	4.00
BNW237	2	2	100	71.40	100	61.36	100	100.00		50	7	48.71	3	1.00	1.00	0.00	1.00	0.00	1.00	10.00	4.00	2.00	0.00	0.00	4.00	4.00
BNW265	2	1	100	92.82	100	97.12	100	57.14	91.67	50	8	52.24	2	0.00	0.00	0.00	1.00	0.00	0.00	16.00	1.00	0.00	0.00	0.00	4.00	1.00
BNW319	3	2	100	85.68	100	74.46	100	100.00		100	7	53.30	3	0.00	1.00	0.00	1.00	0.00	1.00	5.00	3.00	0.00	0.00	0.00	4.00	3.00
BNW323	3	2	100	92.82	100	65.91	100	100.00		100	7	53.23	3	0.00	1.00	0.00	1.00	1.00	1.00	26.00	4.00	0.00	0.00	0.00	4.00	4.00
BNW325	1	1	100	92.82	100	94.23	100	100.00	25.00	0	8	46.49	3	0.00	1.00	0.00	1.00	0.00	1.00	6.00	3.00	0.00	0.00	0.00	1.00	3.00
BNW334	1	2	100	64.26	100	87.50	100	85.71	75.00	0	8	47.17	3	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	3.00	1.00
BNW360	2	3	100	99.96	100	100.00	100	100.00		50	7	54.88	3	0.00	1.00	1.00	1.00	0.00	1.00	10.00	4.00	0.00	0.00	0.00	4.00	4.00
BNW367	1	1	100	75.68	100	94.64	100	71.43		0	7	48.50	3	0.00	0.00	0.00	1.00	1.00	1.00	12.00	3.00	0.00	0.00	0.00	4.00	3.00
BNW382	2	3	100	91.39	100	100.00	100	57.14		50	7	51.79	3	1.00	0.00	0.00	0.00	0.00	0.00	13.00	1.00	7.00	0.00	0.00	1.00	1.00

[16] Age: 1 (young adult), 2 (mid adult) and 3 (older adult)
[17] Sex: 1 (male), 2 (female) and 3 (unknown)
[18] Presence: 0 (not present) and 1 (present)

Burial No.	Age[16]	Sex[17]	Childhood Lesions Score	Joint Disease Score	Trauma Score	Dental Score	EH Score	Pathology Score	Long Bone Length Score	Age Score	No. Attributes	ZScore	Phase	Ornament Presence[18]	Animal Presence	Blade Presence	Pottery Presence	Industry Presence	Other Presence	No. Goods	No. Types	No. Ornaments	Wild Animal Presence	Special Ornament Presence	Orientation	No. Variables
BNW383	2	2	100	87.50	100	90.32	100	85.71		50	7	52.07	3	0.00	1.00	1.00	1.00	1.00	1.00	29.00	5.00	0.00	0.00	0.00	4.00	5.00
BNW390	2	1	100	91.67	100	66.81	100	85.71	83.33	50	8	50.40	3	0.00	1.00	1.00	1.00	0.00	1.00	27.00	4.00	0.00	0.00	0.00	4.00	4.00
BNW392	2	1	100	85.68	100	92.97	50	57.14	78.13	50	8	48.47	1	0.00	1.00	0.00	1.00	0.00	1.00	11.00	3.00	0.00	0.00	0.00	1.00	3.00
BNW407	3	2	100	57.12	100	43.97	100	85.71		100	7	47.09	1	1.00	1.00	0.00	1.00	0.00	1.00	15.00	4.00	7.00	0.00	0.00	1.00	4.00
BNW408	3	1	100	78.54	100	64.66	50	85.71	81.25	100	8	49.06	1	1.00	0.00	0.00	1.00	0.00	0.00	15.00	2.00	5.00	0.00	0.00	1.00	2.00
BNW415	1	3	100	75.00	100	97.58	100	85.71	100.00	0	8	51.00	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
BNW416	1	2	100	92.82	100	80.00	100	100.00	75.00	0	8	49.67	1	0.00	0.00	0.00	1.00	0.00	1.00	4.00	2.00	0.00	0.00	0.00	1.00	2.00
BNW419	1	2	100	71.40	100	100.00	100	85.71		0	7	49.31	3	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	4.00	1.00
BNW431	3	1	100	64.26	90	82.81	100	100.00	81.25	100	8	49.61	1	1.00	0.00	0.00	1.00	0.00	1.00	24.00	3.00	7.00	0.00	0.00	3.00	3.00
BNW433	2	2	100	92.82	100	100.00	100	100.00	91.67	50	8	54.43	3	0.00	1.00	0.00	1.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	4.00	2.00
BNW449	1	2	100	67.12	100	97.50	100	100.00	82.50	0	8	49.48	1	1.00	0.00	0.00	1.00	0.00	1.00	8.00	3.00	2.00	0.00	0.00	1.00	3.00
BNW474	1	2	100	91.67	100	70.31	100	85.71	87.50	0	8	49.23	3	0.00	1.00	0.00	1.00	0.00	1.00	4.00	3.00	0.00	0.00	0.00	1.00	3.00
BNW535	2	2	100	67.12	80	87.50	100	85.71	75.00	50	8	45.23	1	1.00	0.00	0.00	1.00	0.00	1.00	8.00	3.00	2.00	0.00	0.00	1.00	3.00
BNW539	2	1	100	92.82	90	100.00	100	85.71	100.00	50	8	52.50	1	0.00	0.00	0.00	1.00	0.00	1.00	4.00	2.00	0.00	0.00	0.00	1.00	2.00
BNW549	2	1	100	71.40	100	63.89	50	85.71	75.00	50	8	46.06	1	0.00	1.00	0.00	1.00	1.00	1.00	27.00	4.00	0.00	0.00	0.00	1.00	4.00
BNW554	2	2	100	92.82	80	97.50	100	85.71	75.00	50	8	48.18	1	1.00	0.00	0.00	1.00	0.00	0.00	4.00	2.00	1.00	0.00	0.00	1.00	2.00
NUL001	2	1	100	100.00	100	100.00	50	100.00	75.00	50	8	51.93	4	1.00	0.00	0.00	1.00	0.00	0.00	33.00	2.00	30.00	0.00	0.00	1.00	2.00
NUL004	1	3	100	100.00	100	100.00	0	100.00		0	7	48.97	4	1.00	0.00	1.00	1.00	0.00	0.00	9.00	3.00	5.00	0.00	1.00	1.00	3.00
NUL005	1	1	100	100.00	100	100.00	50	100.00	91.67	0	8	51.56	4	1.00	0.00	1.00	0.00	0.00	0.00	4.00	2.00	2.00	0.00	1.00	1.00	2.00
NUL010	3	2	100		100	68.75	50	100.00	100.00	100	7	52.77	4	1.00	0.00	1.00	0.00	0.00	0.00	16.00	2.00	14.00	0.00	1.00	1.00	2.00
NUL012	3	2	100	100.00	100	97.50	100	100.00		100	7	56.72	4	1.00	0.00	1.00	1.00	0.00	0.00	6.00	3.00	2.00	0.00	0.00	1.00	3.00
NUL014	2	1	100	100.00	100	92.86	100	100.00	75.00	50	8	53.06	4	1.00	0.00	1.00	1.00	0.00	1.00	141.00	4.00	131.00	0.00	1.00	1.00	4.00
NUL026	1	1	100	56.80	100	71.43	0	0.00	81.82	0	8	40.36	3	1.00	1.00	0.00	1.00	0.00	1.00	13.00	4.00	2.00	1.00	0.00	1.00	4.00
NUL027	2	1	100	63.90	80	84.48	100	85.71	77.08	50	8	44.90	3	1.00	1.00	1.00	1.00	1.00	1.00	53.00	6.00	5.00	1.00	0.00	3.00	6.00
NUL030	1	2	100		100	80.77	100	100.00	85.00	0	7	50.19	3	1.00	1.00	0.00	0.00	0.00	1.00	19.00	3.00	16.00	0.00	1.00	2.00	3.00
NUL033	1	1	100		100	91.00	100	100.00	81.25	0	7	50.72	3	1.00	0.00	0.00	0.00	0.00	1.00	3.00	2.00	2.00	0.00	0.00	2.00	2.00
NUL035	2	2	100	100.00	100	79.00	100	100.00	62.50	50	8	50.92	3	1.00	0.00	0.00	0.00	1.00	1.00	20.00	3.00	16.00	0.00	1.00	2.00	3.00
NUL036	1	2	100	85.80	100	72.50	0	0.00	81.25	0	8	38.56	3	1.00	0.00	0.00	0.00	0.00	0.00	3.00	1.00	3.00	0.00	0.00	2.00	1.00
NUL037	3	2	100	75.74	100	79.17	100	100.00	70.00	100	8	51.32	3	1.00	1.00	0.00	0.00	0.00	0.00	8.00	2.00	7.00	0.00	1.00	2.00	2.00
NUL039	1	1	100	100.00	100	93.75	50	100.00	100.00	0	8	51.79	3	1.00	0.00	0.00	0.00	0.00	1.00	8.00	2.00	7.00	0.00	0.00	2.00	2.00
NUL040	1	2	100	100.00	100	97.32	0	100.00	75.00	0	8	48.24	3	1.00	1.00	0.00	0.00	1.00	1.00	8.00	4.00	4.00	0.00	1.00	2.00	4.00

Burial No.	Age[16]	Sex[17]	Childhood Lesions Score	Joint Disease Score	Trauma Score	Dental Score	EH Score	Pathology Score	Long Bone Length Score	Age Score	No. Attributes	ZScore	Phase	Ornament Presence[18]	Animal Presence	Blade Presence	Pottery Presence	Industry Presence	Other Presence	No. Goods	No. Types	No. Ornaments	Wild Animal Presence	Special Ornament Presence	Orientation	No. Variables
NUL042	3	1	100	58.58	80	85.58	100	0.00	100.00	100	8	44.35	3	1.00	1.00	0.00	1.00	0.00	0.00	3.00	3.00	1.00	0.00	0.00	2.00	3.00
NUL044	1	1	100	100.00	100	97.66	0	100.00	79.17	0	8	48.62	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00
NUL049	2	2	100	100.00	100	100.00	100	100.00	100.00	50	8	55.75	3	1.00	1.00	0.00	0.00	0.00	1.00	6.00	3.00	4.00	0.00	0.00	2.00	3.00
NUL050	1	1	100	100.00	100	87.50	0	100.00	100.00	0	8	49.62	3	1.00	0.00	0.00	0.00	0.00	1.00	4.00	2.00	2.00	0.00	0.00	2.00	2.00
NUL052	3	2	100	100.00	100	23.08	100	100.00		100	7	50.15	3	1.00	0.00	0.00	0.00	1.00	1.00	6.00	3.00	4.00	0.00	0.00	2.00	3.00
NUL059	1	3	100	100.00	100	96.43	100	100.00		0	7	54.51	4	1.00	0.00	1.00	1.00	0.00	0.00	16.00	3.00	10.00	0.00	1.00	4.00	3.00
NUL060	1	1	100	100.00	100	100.00	100	100.00	75.00	0	8	51.82	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
NUL061	1	1	100	100.00	100	100.00	100	100.00	58.33	0	8	50.39	4	1.00	0.00	0.00	0.00	0.00	0.00	4.00	1.00	4.00	0.00	0.00	4.00	1.00
NUL062	2	2	100	100.00	100	86.67	100	100.00	50.00	50	8	50.45	4	1.00	0.00	1.00	1.00	0.00	1.00	68.00	4.00	63.00	0.00	1.00	1.00	4.00
NUL066	2	1	100	100.00	100	100.00	100	100.00	75.00	50	8	53.62	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
NUL067	1	3	100	100.00	100	94.00	100	100.00		0	7	52.30	4	1.00	0.00	0.00	0.00	0.00	1.00	3.00	2.00	2.00	0.00	0.00	4.00	2.00
NUL069	1	1	100	100.00	100	94.23	100	100.00	83.33	0	8	52.08	4	1.00	0.00	1.00	1.00	0.00	1.00	104.00	4.00	98.00	0.00	0.00	4.00	4.00
NUL073	2	3	100		100	65.00	50	100.00		50	6	48.48	4	1.00	0.00	1.00	1.00	0.00	0.00	20.00	3.00	16.00	0.00	1.00	4.00	3.00
NUL074	1	1	100	100.00	100	97.50	50	100.00	100.00	0	8	52.08	4	1.00	0.00	0.00	1.00	0.00	0.00	6.00	2.00	3.00	0.00	0.00	4.00	2.00
NUL075	1	3	100	100.00	100	94.23	100	100.00		0	7	52.32	4	1.00	0.00	1.00	1.00	0.00	0.00	9.00	3.00	2.00	0.00	0.00	1.00	3.00
NUL076	2	3	100		100	100.00	50	100.00		50	6	52.08	4	1.00	0.00	1.00	1.00	1.00	1.00	20.00	5.00	15.00	0.00	0.00	4.00	5.00
NUL078	2	3	100	92.90	80	100.00	100	14.29		50	7	45.13	4	1.00	0.00	0.00	0.00	0.00	1.00	7.00	2.00	6.00	0.00	0.00	4.00	2.00
NUL082	2	2	100	100.00	100	85.71	100	100.00		50	7	53.62	4	1.00	0.00	0.00	1.00	1.00	0.00	19.00	3.00	14.00	0.00	0.00	4.00	3.00
NUL094	3	1	100	85.70	100	69.00	0	85.71	100.00	100	8	49.92	4	1.00	0.00	0.00	0.00	0.00	0.00	5.00	1.00	5.00	0.00	1.00	3.00	1.00
NUL096	2	3	100	100.00	100		100	100.00		50	6	54.13	4	1.00	0.00	1.00	1.00	0.00	1.00	27.00	4.00	23.00	0.00	0.00	4.00	4.00
NUL098	3	1	100	100.00	100	65.00	100	100.00	62.50	100	8	51.64	4	1.00	0.00	1.00	1.00	1.00	1.00	25.00	5.00	20.00	0.00	0.00	1.00	5.00
NUL099	3	2	100	100.00	100	76.56	100	100.00	90.00	100	8	54.89	4	1.00	0.00	0.00	1.00	1.00	0.00	22.00	3.00	16.00	0.00	1.00	1.00	3.00
NUL104	1	2	100	100.00	100	100.00	50	100.00		0	7	50.90	4	1.00	0.00	0.00	1.00	0.00	0.00	26.00	2.00	20.00	0.00	1.00	1.00	2.00
NUL107	1	1	100	100.00	80	100.00	100	0.00	67.50	0	8	42.59	3	0.00	1.00	0.00	1.00	0.00	0.00	6.00	2.00	0.00	0.00	0.00	3.00	2.00
NUL108	3	2	100	42.90	80	36.29	100	100.00	90.63	100	8	43.02	3	1.00	1.00	0.00	1.00	0.00	1.00	9.00	4.00	3.00	0.00	0.00	3.00	4.00
NUL110	2	2	100		100	63.00	100	100.00	75.00	50	7	49.69	4	1.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00	2.00	0.00	0.00	3.00	1.00
NUL111	1	1	100	100.00	100	94.74	100	85.71		0	7	51.61	4	1.00	0.00	0.00	1.00	0.00	1.00	9.00	3.00	7.00	0.00	0.00	4.00	3.00
NUL113	1	2	100	100.00	100	72.22	0	100.00	100.00		8	48.44	4	1.00	0.00	1.00	1.00	0.00	1.00	68.00	4.00	62.00	0.00	1.00	1.00	4.00

Appendix F Correlations and Significant Relationships

Table A 32: Significant differences following independent samples t-test calculations (p<0.05) (* special ornaments were not identified at Ban Non Wat and therefore cannot be tested using data that includes Ban Non Wat).

	Both BNW and NUL	BNW	NUL	All Males	All Females	BNW Males	BNW Females	NUL Males	NUL Females	Mid Bronze Age	Late Bronze Age	Early Iron Age	Mid Iron Age
With Ornaments vs No Ornaments	N	Sig.	N	N	N	N	Sig.	N	N	N	N	N	N
With Animal vs No Animal	Sig.	N	Sig.	Sig.	N	N	N	Sig.	N	N	N	N	N
With Blade vs No Blade	Sig.	N	N	N	N	N	N	N	N	N	N	N	N
With Pottery vs No Pottery	N	N	N	Sig.	N	N	N	N	N	N	N	N	N
With Industrial vs No Industrial	N	N	N	N	N	N	N	N	N	N	N	N	N
With Other vs No Other	N	N	N	N	N	N	N	N	N	N	N	N	N
With Special Ornaments vs No Special Ornaments*	-	-	N	-	-	-	-	N	N	-	-	-	N
With Ornaments and Pottery vs No Ornaments and Pottery	N	Sig.	N	N	N	N	Sig.	N	N	N	N	Sig.	N
With Ornaments and Animal vs No Ornaments and Animal	Sig.	N	Sig.	Sig.	N	N	N	Sig.	N	N	N	N	N
With Ornaments and Blade vs No Ornaments and Blade	N	N	N	N	N	N	N	N	N	N	N	N	N
With Ornaments and Industry vs No Ornaments and Industry	N	N	N	N	N	N	Sig.	N	N	N	N	N	N

	Both BNW and NUL	BNW	NUL	All Males	All Females	BNW Males	BNW Females	NUL Males	NUL Females	Mid Bronze Age	Late Bronze Age	Early Iron Age	Mid Iron Age
With Ornaments and Other vs No Ornaments and Other	N	Sig.	N	N	Sig.	N	Sig.	N	N	N	N	N	N
With Animal and Other vs No Animal and Other	Sig.	N	Sig.	Sig.	N	N	N	Sig.	N	N	N	N	N
With Animal and Blade vs No Animal and Blade	N	N	N	N	N	N	N	N	N	N	N	N	N
With Animal and Pottery vs No Animal and Pottery	Sig.	N	Sig.	Sig.	N	N	N	Sig.	N	N	N	N	N
With Animal and Industry vs No Animal and Industry	N	N	N	N	N	N	N	N	N	Sig.	N	N	N
With Blade and Pottery vs No Blade and Pottery	N	N	N	N	N	N	N	N	N	N	N	N	N
With Blade and Industry vs No Blade and Industry	N	N	N	N	N	N	N	N	N	N	N	N	N
With Pottery and Other vs No Pottery and Other	N	N	N	N	N	N	N	N	N	N	N	N	N
With Pottery and Industry vs No Pottery and Industry	N	N	N	N	N	N	N	N	N	N	N	N	N
With Industry and Other vs No Industry and Other	N	N	N	N	N	Sig.	N	N	N	N	N	N	N
With Ornaments, Pottery and Other vs No Ornaments, Pottery and Other	Sig.	Sig.	N	N	Sig.	N	Sig.	N	N	N	N	Sig.	N

Table A 33: Assessment of significant differences between health and burial factors using one-way ANOVA ($p<0.05$).

	Both BNW and NUL	BNW	NUL	All Males	All Females	BNW Males	BNW Females	NUL Males	NUL Females	Mid Bronze Age	Late Bronze Age	Early Iron Age	Mid Iron Age
Orientation	Sig.	Sig.	Sig.	N	N	N	N	N	N	N	N	Sig.	N
No. of variables	N	N	N	N	Sig.	N	N	N	Sig.	Sig.	N	N	N

Table A 34: Correlations at Ban Non Wat: Pig bone and number of artefacts and ornaments.

		No. Artefacts	No. Ornaments	Pig Bone
No. Artefacts	Pearson Correlation	1	.258	.458**
	Sig. (2-tailed)		.117	.004
	N	38	38	38
No .Ornaments	Pearson Correlation	.258	1	.013
	Sig. (2-tailed)	.117	0	.938
	N	38	38	38
Pig bone	Pearson Correlation	.458**	.013	1
	Sig. (2-tailed)	.004	.938	
	N	38	38	38

**. Correlation is significant at the 0.01 level (2-tailed).

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Appendix G T-Tests

Appendix G.1 Ban Non Wat and Noen U-Loke

Table A 35: T-test – Animal Bone.

	Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal Bone	52	50.8688	2.90202	.40244
	Has Animal Bone	29	48.6545	4.01369	.74532

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	4.351	.040	2.862	79	.005	2.21433	.77377	.67418	3.75449
	Equal variances not assumed			2.614	44.624	.012	2.21433	.84703	.50793	3.92074

Table A 36: T-test – Blade.

	Blade	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Blade	62	49.6247	3.53463	.44890
	Has Blade	19	51.5487	2.94318	.67521

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.843	.361	-2.152	79	.034	-1.92395	.89389	-3.70320	-.14470
	Equal variances not assumed			-2.373	35.388	.023	-1.92395	.81082	-3.56935	-.27855

Table A 37: T-test – Ornaments, Pottery and Other goods.

	Ornament/Pottery/Other vs no Ornament/Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/ Pottery /Other	57	50.6507	3.18197	.42146
	Has Ornament/Pottery and Other	24	48.7112	3.85236	.78636

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	1.792	.185	2.351	79	.021	1.93955	.82510	.29723	3.58188
	Equal variances not assumed			2.174	36.863	.036	1.93955	.89218	.13159	3.74752

Table A 38: T-Test – Animal and Ornaments.

	Ornament/Animal vs no Ornament/Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Animal	65	50.6579	3.07228	.38107
	Has Ornament and Animal	16	47.7123	4.13425	1.03356

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	1.768	.187	3.198	79	.002	2.94551	.92104	1.11222	4.77880
	Equal variances not assumed			2.674	19.272	.015	2.94551	1.10157	.64209	5.24894

Table A 39: T-test – Animal and Other Goods.

	Animal/Other vs no Animal/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Other	58	50.6653	3.16774	.41594
	Has Animal and Other	23	48.5900	3.86692	.80631

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.916	.342	2.494	79	.015	2.07524	.83214	.41890	3.73158
	Equal variances not assumed			2.287	34.329	.028	2.07524	.90727	.23209	3.91839

Table A 40: T-test – Animal and Pottery.

	Animal/Pottery vs no Animal/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Pottery	57	50.8395	2.91117	.38559
	With Animal and Pottery	24	48.2628	4.09209	.83529

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	4.882	.030	3.210	79	.002	2.57669	.80273	.97890	4.17448
	Equal variances not assumed			2.801	33.227	.008	2.57669	.92000	.70542	4.44795

Table A 41: One-Way ANOVA – Orientation.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
North	36	49.9172	3.26932	.54489	48.8110	51.0234	40.36	56.72
North East	12	49.5650	3.83296	1.10648	47.1297	52.0004	41.05	55.75
East	11	47.4208	3.73372	1.12576	44.9124	49.9291	42.59	55.45
South	22	51.9423	2.56845	.54760	50.8035	53.0811	45.13	54.88
Total	81	50.0760	3.48544	.38727	49.3053	50.8467	40.36	56.72

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.484	3	77	.694

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	158.219	3	52.740	4.991	.003
Within Groups	813.647	77	10.567		
Total	971.866	80			

SEAHI Score

Tukey HSD

(I) Orientation	(J) Orientation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
North	North East	.35217	1.08356	.988	-2.4933	3.1976
	East	2.49639	1.11989	.125	-.4445	5.4372
	South	-2.02510	.87968	.106	-4.3352	.2850
North East	North	-.35217	1.08356	.988	-3.1976	2.4933
	East	2.14422	1.35691	.396	-1.4191	5.7075
	South	-2.37727	1.16657	.183	-5.4407	.6862
East	North	-2.49639	1.11989	.125	-5.4372	.4445
	North East	-2.14422	1.35691	.396	-5.7075	1.4191
	South	-4.52149*	1.20039	.002	-7.6738	-1.3692
South	North	2.02510	.87968	.106	-.2850	4.3352
	North East	2.37727	1.16657	.183	-.6862	5.4407
	East	4.52149*	1.20039	.002	1.3692	7.6738

*. The mean difference is significant at the 0.05 level.

Appendix G.2 All Males

Table A 42: T-Test - Animal Bone.

	Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal Bone	22	51.1971	1.96702	.41937
	Has Animal Bone	13	46.6754	3.77700	1.04755

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	5.956	.020	4.673	33	.000	4.52174	.96755	2.55324	6.49023
	Equal variances not assumed			4.007	15.921	.001	4.52174	1.12838	2.12872	6.91476

Table A 43: T-Test – Pottery.

	Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Pottery	9	51.1232	1.60290	.53430
	Has Pottery	26	48.9618	3.83525	.75215

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	5.710	.023	1.629	33	.113	2.16137	1.32661	-.53764	4.86038
	Equal variances not assumed			2.343	31.517	.026	2.16137	.92261	.28094	4.04180

Table A 44: T-Test – Ornaments and Animal.

	Ornament/Animal vs no Ornament/Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Animal	27	50.3832	2.73218	.52581
	Has Ornament and Animal	8	46.5963	4.42279	1.56369

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	3.664	.064	2.970	33	.006	3.78691	1.27489	1.19313	6.38069
	Equal variances not assumed			2.295	8.643	.048	3.78691	1.64973	.03131	7.54251

Table A 45: T-Test – Animal and Other Goods.

	Animal/Other vs no Animal/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	Has Animal and Other	10	46.6298	3.36378	1.06372
	No Animal/Other	25	50.6727	2.89344	.57869

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.152	.699	-3.567	33	.001	-4.04294	1.13333	-6.34873	-1.73716
	Equal variances not assumed			-3.339	14.635	.005	-4.04294	1.21094	-6.62962	-1.45626

Table A 46: T-Test – Animal and pottery.

	No Animal/Pottery vs no No Animal/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Pottery	22	51.1971	1.96702	.41937
	With Animal and Pottery	13	46.6754	3.77700	1.04755

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	5.956	.020	4.673	33	.000	4.52174	.96755	2.55324	6.49023
	Equal variances not assumed			4.007	15.921	.001	4.52174	1.12838	2.12872	6.91476

Appendix G.3 All Females

Table A 47: One-way ANOVA – Number of burial good types.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	5	47.4462	3.74387	1.67431	42.7976	52.0948	41.05	50.01
2.00	6	51.5546	2.31426	.94479	49.1260	53.9833	48.18	54.43
3.00	12	52.0773	3.41841	.98681	49.9054	54.2493	45.23	56.72
4.00	8	48.2056	3.28056	1.15985	45.4629	50.9482	43.02	53.23
5.00	1	52.0662	.	.	.	.	52.07	52.07
6.00	1	46.3086	.	.	.	.	46.31	46.31
Total	33	50.1668	3.65869	.63690	48.8695	51.4642	41.05	56.72

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.486[a]	3	27	.695

a. Groups with only one case are ignored in computing the test of homogeneity of variance for SEAHI Score.

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	141.632	5	28.326	2.667	.044
Within Groups	286.720	27	10.619		
Total	428.352	32			

Table A 48: T-test – No. of burial good types – 1 vs 3.

	No.variables	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	1.00	5	47.4462	3.74387	1.67431
	3.00	12	52.0773	3.41841	.98681

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.046	.833	-2.480	15	.025	-4.63114	1.86736	-8.61131	-.65096
	Equal variances not assumed			-2.383	6.956	.049	-4.63114	1.94348	-9.23257	-.02970

Table A 49: T-Test – No of burial good types – 3 vs 4.

	No.variables	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	3.00	12	52.0773	3.41841	.98681
	4.00	8	48.2056	3.28056	1.15985

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.269	.611	2.520	18	.021	3.87177	1.53612	.64450	7.09904
	Equal variances not assumed			2.542	15.600	.022	3.87177	1.52284	.63675	7.10679

Table A 50: T-test – Ornaments and Other goods.

	Ornament/Other vs no Ornament/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Other	19	51.3190	3.61241	.82874
	With Ornament and Other	14	48.6032	3.21064	.85808

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.188	.667	2.235	31	.033	2.71585	1.21503	.23778	5.19393
	Equal variances not assumed			2.277	29.823	.030	2.71585	1.19294	.27893	5.15278

Table A 51: T-test – Ornaments, Pottery and Other goods.

	Ornament/Pottery/Other vs no Ornament/Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery/Other	24	51.2631	3.40574	.69519
	Has Ornament Pottery and Other	9	47.2436	2.64153	.88051

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.300	.588	3.188	31	.003	4.01953	1.26090	1.44790	6.59115
	Equal variances not assumed			3.583	18.572	.002	4.01953	1.12187	1.66776	6.37130

Appendix G.4 Noen U-Loke

Table A 52: T-Test – Animal. .

	Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal Bone	34	51.4589	2.90597	.49837
	Has Animal Bone	9	46.7463	4.96599	1.65533

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	6.851	.012	3.690	41	.001	4.71259	1.27723	2.13318	7.29200
	Equal variances not assumed			2.726	9.497	.022	4.71259	1.72873	.83292	8.59225

Table A 53: Oneway ANOVA – Orientation.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
North	15	51.5529	3.61982	.93463	49.5483	53.5575	40.36	56.72
North East	12	49.5650	3.83296	1.10648	47.1297	52.0004	41.05	55.75
East	5	46.0241	3.56155	1.59277	41.6019	50.4464	42.59	49.92
South	11	52.0112	2.92980	.88337	50.0430	53.9795	45.13	54.57
Total	43	50.4725	3.88527	.59250	49.2768	51.6682	40.36	56.72

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.238	3	39	.869

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	152.377	3	50.792	4.113	.013
Within Groups	481.627	39	12.349		
Total	634.004	42			

Post Hoc Tests

SEAHI Score
Tukey HSD

(I) Orientation	(J) Orientation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
North	North East	1.98791	1.36103	.470	-1.6642	5.6401
	East	5.52880*	1.81471	.021	.6593	10.3983
	South	-.45830	1.39498	.988	-4.2015	3.2849
North East	North	-1.98791	1.36103	.470	-5.6401	1.6642
	East	3.54089	1.87056	.248	-1.4785	8.5603
	South	-2.44621	1.46690	.354	-6.3824	1.4900
East	North	-5.52880*	1.81471	.021	-10.3983	-.6593
	North East	-3.54089	1.87056	.248	-8.5603	1.4785
	South	-5.98711*	1.89540	.016	-11.0732	-.9010
South	North	.45830	1.39498	.988	-3.2849	4.2015
	North East	2.44621	1.46690	.354	-1.4900	6.3824
	East	5.98711*	1.89540	.016	.9010	11.0732

*. The mean difference is significant at the 0.05 level.

Table A 54: T-Test – Ornaments and Animal.

	Ornament/Animal vs no Ornament/Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Animal	35	51.2055	3.23172	.54626
	Has Ornament and Animal	8	47.2659	5.04052	1.78209

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	4.080	.050	2.788	41	.008	3.93954	1.41288	1.08618	6.79290
	Equal variances not assumed			2.114	8.362	.066	3.93954	1.86393	-.32652	8.20560

Table A 55: T-Test – Animal and Other Goods.

	Animal/Other vs no Animal/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Other	37	51.0233	3.33721	.54863
	Has Animal and Other	6	47.0763	5.52528	2.25568

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	3.384	.073	2.441	41	.019	3.94698	1.61716	.68105	7.21290
	Equal variances not assumed			1.700	5.606	.143	3.94698	2.32145	-1.83150	9.72545

Table A 56: T-Test – Animal and Pottery.

	Animal/Pottery vs no Animal/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Pottery	38	51.4501	2.89044	.46889
	With Animal and Pottery	5	43.0427	1.77162	.79229

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.852	.361	6.309	41	.000	8.40742	1.33252	5.71633	11.09850
	Equal variances not assumed			9.132	7.197	.000	8.40742	.92064	6.24248	10.57236

Appendix G.5 Noen U-Loke – Males

Table A 57: T-test – Animal Bone.

	Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal Bone	15	51.8777	1.65505	.42733
	Has Animal Bone	4	43.0490	2.04562	1.02281

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.273	.608	9.067	17	.000	8.82876	.97375	6.77433	10.88318
	Equal variances not assumed			7.965	4.112	.001	8.82876	1.10849	5.78384	11.87367

Table A 58: T-test – Ornaments and Animal.

	Ornament/Animal vs no Ornament/Animal	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Animal	16	51.2972	2.81936	.70484
	Has Ornament and Animal	3	43.2022	2.47709	1.43015

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.000	.985	4.626	17	.000	8.09499	1.74985	4.40312	11.78685
	Equal variances not assumed			5.077	3.065	.014	8.09499	1.59440	3.08164	13.10834

Table A 59: T-test – Animal and Other goods.

	Animal/Other vs no Animal/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Other	17	50.8883	3.20845	.77816
	Has Animal and Other	2	42.6302	3.21075	2.27034

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.002	.967	3.443	17	.003	8.25809	2.39856	3.19757	13.31862
	Equal variances not assumed			3.441	1.248	.139	8.25809	2.40000	-11.07271	27.58890

Table A 60: T-Test - Animal and pottery.

	Animal/Pottery vs no Animal/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal and Pottery	15	51.8777	1.65505	.42733
	With Animal and Pottery	4	43.0490	2.04562	1.02281

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.273	.608	9.067	17	.000	8.82876	.97375	6.77433	10.88318
	Equal variances not assumed			7.965	4.112	.001	8.82876	1.10849	5.78384	11.87367

Appendix G.6 Noen U-Loke - Females

Table A 61: Oneway ANOVA and Chi-square test – Number of burial good types.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	2	45.3725	6.11223	4.32200	-9.5437	100.2887	41.05	49.69
2.00	3	52.3510	.89446	.51642	50.1290	54.5730	51.32	52.96
3.00	7	53.1764	2.75291	1.04050	50.6304	55.7224	50.15	56.72
4.00	4	47.9856	3.45819	1.72910	42.4828	53.4883	43.02	50.45
Total	16	50.7485	4.14418	1.03604	48.5402	52.9567	41.05	56.72

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
3.636	3	12	.045

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	137.305	3	45.768	4.565	.024
Within Groups	120.308	12	10.026		
Total	257.613	15			

Test Statistics[a,b]

	SEAHI Score
Chi-Square	8.322
df	3
Asymp. Sig.	.040

a. Kruskal Wallis Test

b. Grouping Variable: No.variables

Post Hoc Tests

Multiple Comparisons

SEAHI Score

Tukey HSD

(I) No.variables	(J) No.variables	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-6.97850	2.89045	.127	-15.5600	1.6030
	3.00	-7.80393*	2.53871	.042	-15.3411	-.2667
	4.00	-2.61309	2.74212	.778	-10.7542	5.5280
2.00	1.00	6.97850	2.89045	.127	-1.6030	15.5600
	3.00	-.82543	2.18498	.981	-7.3124	5.6615
	4.00	4.36542	2.41833	.318	-2.8144	11.5452
3.00	1.00	7.80393*	2.53871	.042	.2667	15.3411
	2.00	.82543	2.18498	.981	-5.6615	7.3124
	4.00	5.19084	1.98460	.091	-.7012	11.0829
4.00	1.00	2.61309	2.74212	.778	-5.5280	10.7542
	2.00	-4.36542	2.41833	.318	-11.5452	2.8144
	3.00	-5.19084	1.98460	.091	-11.0829	.7012

*. The mean difference is significant at the 0.05 level.

Appendix G.7 Ban Non Wat

Table A 62: T-Test – Ornaments.

	Ornament	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornaments	20	50.5810	2.81644	.62978
	Has Ornaments	18	48.5678	2.81112	.66259

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.258	.614	2.202	36	.034	2.01323	.91423	.15909	3.86737
	Equal variances not assumed			2.202	35.597	.034	2.01323	.91413	.15855	3.86791

Table A 63: T-test - Ornaments and Pottery.

	Ornament/Pottery vs no Ornament/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery	22	50.6100	2.69473	.57452
	With Ornament and Pottery	16	48.2762	2.83440	.70860

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.125	.726	2.579	36	.014	2.33379	.90480	.49878	4.16880
	Equal variances not assumed			2.558	31.485	.016	2.33379	.91224	.47442	4.19316

Table A 64: T-test – Ornaments and Other Goods.

	Ornament/Other vs No Ornament/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Other	25	50.5680	2.65679	.53136
	With Ornament and Other	13	47.8184	2.72923	.75695

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.191	.664	2.999	36	.005	2.74968	.91679	.89033	4.60902
	Equal variances not assumed			2.973	23.845	.007	2.74968	.92483	.84026	4.65910

Table A 65: T-Test – Ornaments, Pottery and Other Goods.

	Ornament/Pottery/Other vs no Ornament/Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery/Other	25	50.5680	2.65679	.53136
	Has Ornament Pottery and Other	13	47.8184	2.72923	.75695

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.191	.664	2.999	36	.005	2.74968	.91679	.89033	4.60902
	Equal variances not assumed			2.973	23.845	.007	2.74968	.92483	.84026	4.65910

Table A 66: Oneway ANOVA – Orientation.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
North	21	48.7488	2.46831	.53863	47.6252	49.8724	42.63	52.63
East	6	48.5847	3.76264	1.53609	44.6360	52.5333	44.67	55.45
South	11	51.8733	2.29334	.69147	50.3327	53.4140	48.50	54.88
Total	38	49.6274	2.95668	.47964	48.6555	50.5992	42.63	55.45

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.536	2	35	.590

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	78.221	2	39.111	5.582	.008
Within Groups	245.232	35	7.007		
Total	323.453	37			

Post Hoc Tests

Multiple Comparisons

SEAHI Score

Tukey HSD

(I) Orientation	(J) Orientation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
North	East	.16411	1.22532	.990	-2.8346	3.1628
	South	-3.12455*	.98520	.009	-5.5356	-.7135
East	North	-.16411	1.22532	.990	-3.1628	2.8346
	South	-3.28865*	1.34341	.050	-6.5763	-.0010
South	North	3.12455*	.98520	.009	.7135	5.5356
	East	3.28865*	1.34341	.050	.0010	6.5763

*. The mean difference is significant at the 0.05 level.

Appendix G.8 Ban Non Wat – Males

Table A 67: T-test – Industry and Other Goods.

	Industry/Other vs no Industry/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Industry/Other	12	49.7720	2.23570	.64539
	With Industry and Other	4	46.3726	2.73033	1.36517

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.053	.820	2.505	14	.025	3.39938	1.35705	.48880	6.30995
	Equal variances not assumed			2.251	4.430	.081	3.39938	1.51004	-.63728	7.43603

Appendix G.9 Ban Non Wat – Females

Table A 68: T-Test – Ornaments.

	Ornaments	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornaments	9	51.5398	2.80249	.93416
	Has Ornaments	8	47.4590	1.95924	.69270

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	2.216	.157	3.434	15	.004	4.08081	1.18827	1.54809	6.61354
	Equal variances not assumed			3.509	14.282	.003	4.08081	1.16297	1.59111	6.57052

Table A 69: -T-Test – Ornaments and Pottery.

	Ornament/Pottery vs no Ornament/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornaments and Pottery	10	51.3866	2.68627	.84947
	With Ornaments and Pottery	7	47.0949	1.80035	.68047

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	2.795	.115	3.672	15	.002	4.29166	1.16891	1.80019	6.78313
	Equal variances not assumed			3.943	14.995	.001	4.29166	1.08841	1.97169	6.61163

Table A 70: T-Test – Ornaments and Industrial Goods.

	Ornament/Industry vs no Ornament/Industry	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament and Industry	15	50.1701	2.93053	.75666
	With Ornament and Industry	2	45.4896	1.15818	.81896

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	1.664	.217	2.184	15	.045	4.68045	2.14308	.11259	9.24832
	Equal variances not assumed			4.198	3.266	.021	4.68045	1.11500	1.29005	8.07086

Table A 71: T-Test – Ornaments and Other Goods.

	Ornament/Other vs no Ornament/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Other	11	51.0947	2.72615	.82197
	With Ornament and Other	6	46.9149	1.90188	.77644

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	2.472	.137	3.318	15	.005	4.17981	1.25966	1.49490	6.86471
	Equal variances not assumed			3.697	13.813	.002	4.17981	1.13070	1.75161	6.60801

Table A 72: T-Test – Ornaments, Pottery and Other Goods.

	Ornament/Pottery/Other vs no Ornament/Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery/Other	11	51.0947	2.72615	.82197
	Has Ornament Pottery and Other	6	46.9149	1.90188	.77644

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	2.472	.137	3.318	15	.005	4.17981	1.25966	1.49490	6.86471
	Equal variances not assumed			3.697	13.813	.002	4.17981	1.13070	1.75161	6.60801

Table A 73: T-Test – Pottery, Ornaments, Other Goods and Industry.

	Pottery,Ornament, Other, and Industry	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	With	15	50.1701	2.93053	.75666
	Without	2	45.4896	1.15818	.81896

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	1.664	.217	2.184	15	.045	4.68045	2.14308	.11259	9.24832
	Equal variances not assumed			4.198	3.266	.021	4.68045	1.11500	1.29005	8.07086

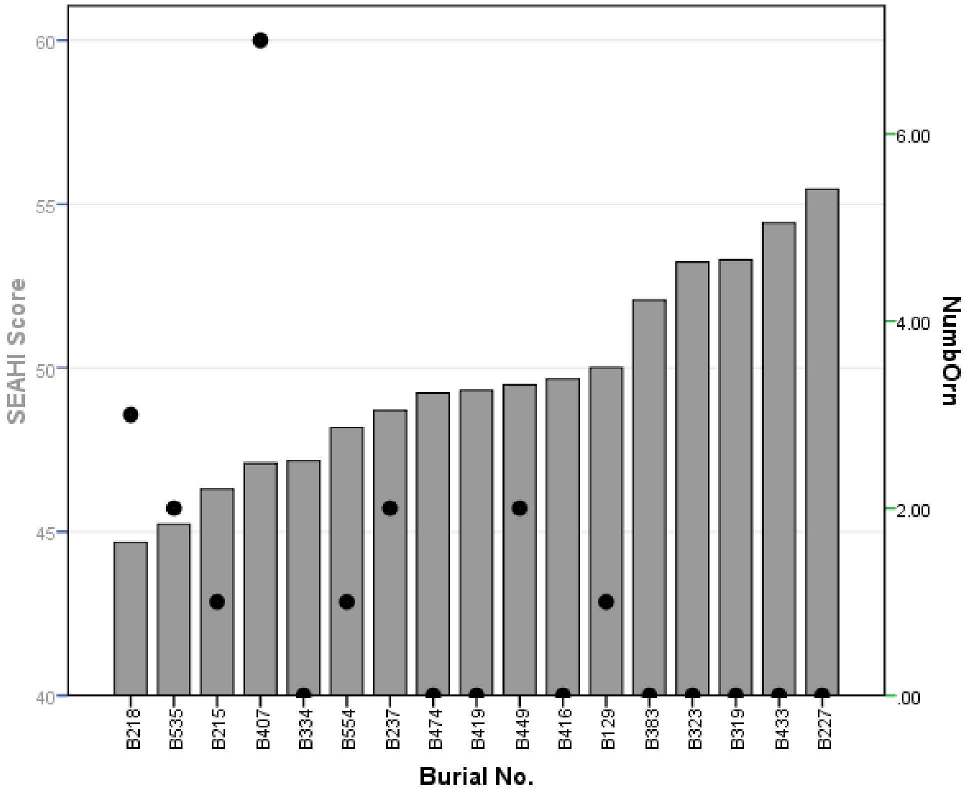

Figure A 1: SEAHI Score and number of ornaments for the females at Ban Non Wat (Bars = SEAHI score and dots = number of ornaments).

Table A 74: Correlation of ornament and artefact numbers with SEAHI for females at Ban Non Wat.

		SEAHI Score	NumbArt	NumbOrn
SEAHI Score	Pearson Correlation	1	.080	-.525*
	Sig. (2-tailed)		.760	.031
	N	17	17	17
NumbArt	Pearson Correlation	.080	1	.124
	Sig. (2-tailed)	.760		.636
	N	17	17	17
NumbOrn	Pearson Correlation	-.525*	.124	1
	Sig. (2-tailed)	.031	.636	
	N	17	17	17

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix G.10 Mid Bronze Age

Table A 75: One-way ANOVA– Number of burial good types.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2.00	4	49.8495	1.86859	.93429	46.8761	52.8228	48.18	52.50
3.00	4	48.1964	2.04327	1.02163	44.9451	51.4477	45.23	49.61
4.00	4	47.3077	.96635	.48317	45.7701	48.8454	46.06	48.30
5.00	1	42.6272	.	.	.	.	42.63	42.63
Total	13	48.0032	2.42248	.67188	46.5393	49.4671	42.63	52.50

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.724[a]	2	9	.511

a. Groups with only one case are ignored in computing the test of homogeneity of variance for SEAHI Score.

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.620	3	14.873	5.188	.024
Within Groups	25.801	9	2.867		
Total	70.421	12			

Table A 76: T-Test – Animal and Industry.

	Animal/Industry vs No Animal/Industry	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Industry	11	48.6683	1.81355	.54681
	With Animal/Industry	2	44.3451	2.42943	1.71787

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.248	.628	2.995	11	.012	4.32320	1.44356	1.14596	7.50045
	Equal variances not assumed			2.398	1.212	.215	4.32320	1.80280	-10.99074	19.63715

Appendix G.11 Late Bronze Age

None

Appendix G.12 Early Iron Age

Table A 77: Oneway ANOVA – Orientation.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
North	6	48.0217	4.17449	1.70423	43.6408	52.4025	40.36	51.79
North East	12	49.5650	3.83296	1.10648	47.1297	52.0004	41.05	55.75
East	4	44.4193	2.09041	1.04521	41.0930	47.7456	42.59	47.17
South	10	51.8369	2.41404	.76339	50.1100	53.5638	48.50	54.88
Total	32	49.3424	3.95349	.69889	47.9170	50.7678	40.36	55.75

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
.545	3	28	.655

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	170.237	3	56.746	5.055	.006
Within Groups	314.297	28	11.225		
Total	484.534	31			

Post Hoc Tests

Multiple Comparisons

SEAHI Score

Tukey HSD

(I) Orientation	(J) Orientation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
North	North East	-1.54335	1.67518	.794	-6.1171	3.0304
	East	3.60240	2.16264	.360	-2.3023	9.5071
	South	-3.81527	1.73012	.147	-8.5390	.9085
North East	North	1.54335	1.67518	.794	-3.0304	6.1171
	East	5.14575	1.93433	.058	-.1356	10.4271
	South	-2.27193	1.43454	.404	-6.1887	1.6448
East	North	-3.60240	2.16264	.360	-9.5071	2.3023
	North East	-5.14575	1.93433	.058	-10.4271	.1356
	South	-7.41767*	1.98210	.004	-12.8294	-2.0059
South	North	3.81527	1.73012	.147	-.9085	8.5390
	North East	2.27193	1.43454	.404	-1.6448	6.1887
	East	7.41767*	1.98210	.004	2.0059	12.8294

*. The mean difference is significant at the 0.05 level.

Table A 78: T-Test – Ornaments and Pottery.

	Ornament/Pottery vs No Ornament/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery	26	50.1569	3.36942	.66080
	With Ornament and Pottery	6	45.8128	4.66282	1.90359

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	1.099	.303	2.652	30	.013	4.34418	1.63829	.99835	7.69001
	Equal variances not assumed			2.156	6.259	.073	4.34418	2.01502	-.53728	9.22563

Table A 79: T-Test – Ornaments, Pottery and Other goods.

	Pottery/Ornament/Other vs No Pottery/Ornament/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/ Pottery /Other	28	50.0705	3.49003	.65955
	Has Ornament, Pottery and Other	4	44.2460	3.50851	1.75426

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.001	.971	3.121	30	.004	5.82449	1.86649	2.01261	9.63637
	Equal variances not assumed			3.108	3.899	.037	5.82449	1.87415	.56766	11.08131

Appendix G.13 Noen U-Loke – Early Iron Age

Table A 80: T-test – Pottery.

	Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Pottery	11	50.0395	3.63173	1.09501
	Has Pottery	5	43.0427	1.77162	.79229

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.652	.433	4.039	14	.001	6.99675	1.73250	3.28092	10.71259
	Equal variances not assumed			5.177	13.774	.000	6.99675	1.35158	4.09342	9.90008

Table A 81: T- test – Ornaments and Pottery.

	Ornament/ Pottery vs no Ornament/ Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament and Pottery	12	49.4186	4.07626	1.17671
	With Ornament and Pottery	4	43.1561	2.02464	1.01232

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.927	.352	2.906	14	.012	6.26254	2.15513	1.64025	10.88483
	Equal variances not assumed			4.035	11.071	.002	6.26254	1.55224	2.84877	9.67631

Table A 82: T-test – Animal and Pottery.

	Animal/Pottery vs No Animal/Pottery	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Animal/Pottery	11	50.0395	3.63173	1.09501
	With Animal and Pottery	5	43.0427	1.77162	.79229

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.652	.433	4.039	14	.001	6.99675	1.73250	3.28092	10.71259
	Equal variances not assumed			5.177	13.774	.000	6.99675	1.35158	4.09342	9.90008

Table A 83: T-test – Pottery and Other goods.

	Pottery/Other vs no Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Pottery/Other	13	49.0284	4.14854	1.15060
	With Pottery and Other	3	42.7594	2.28134	1.31713

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.958	.344	2.486	14	.026	6.26906	2.52132	.86137	11.67675
	Equal variances not assumed			3.585	5.667	.013	6.26906	1.74892	1.92793	10.61018

Table A 84: T-test – Ornaments, Pottery and Other goods.

	Pottery/Ornament/Other vs No Ornament/Pottery/Other	N	Mean	Std. Deviation	Std. Error Mean
SEAHI Score	No Ornament/Pottery/Other	13	49.0284	4.14854	1.15060
	Has Ornament Pottery and Other	3	42.7594	2.28134	1.31713

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEAHI Score	Equal variances assumed	.958	.344	2.486	14	.026	6.26906	2.52132	.86137	11.67675
	Equal variances not assumed			3.585	5.667	.013	6.26906	1.74892	1.92793	10.61018

Table A 85: One Way ANOVA – Orientation.

SEAHI Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
North	1	40.3599	.	.	.	.	40.36	40.36
North East	12	49.5650	3.83296	1.10648	47.1297	52.0004	41.05	55.75
East	3	43.5025	1.22957	.70989	40.4481	46.5569	42.59	44.90
Total	16	47.8530	4.56604	1.14151	45.4199	50.2860	40.36	55.75

Test of Homogeneity of Variances

SEAHI Score

Levene Statistic	df1	df2	Sig.
1.225[a]	1	13	.289

a. Groups with only one case are ignored in computing the test of homogeneity of variance for SEAHI Score.

ANOVA

SEAHI Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	148.100	2	74.050	5.847	.015
Within Groups	164.631	13	12.664		
Total	312.730	15			

Appendix G.14 Mid Iron Age

None