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Seasonal variations in fitness of male and female soccer players in the tropics

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I recognize the infrastructural contribution of James Cook University through providing me with access to resources and equipment for data collection, analysis and the development and completion of this thesis. An account of the contribution of others for the completion of this thesis is detailed below.

Nature of Assistance	Contribution	Names, Titles and Affiliations of Co-Contributors
Intellectual Support	Proposal Writing	Dr Glen Deakin (JCU) Professor Andrew Edwards (University of St Mark & St John) Kelly Sinclair (JCU)
	Data Analysis	Dr Glen Deakin (JCU)
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I recognize the editorial assistance of my supervisory team in the publication of Chapters 3, 4, 9 and 12 (Appendix). Below is an account of others' contribution to the completion of the manuscripts.

Chapter Number	**Details of publication on which chapter is based**	**Nature and extent of the intellectual input of each author, including the candidate**
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I declare that all persons whom have provided sufficient contribution to this thesis have been included as co-authors or have been acknowledged in published papers or papers currently under review in peer-reviewed journals.

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Declaration on ethics

The studies as part of this doctoral degree were conducted in accordance with the research ethics guidelines of the *World Medical Association Declaration of Helsinki- Ethical Principles for Medical Research Involving Human Subjects (2008), the Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997*) and the *James Cook University Statement and Guidelines on Research Practice (2001).*

The research methodology and protocols of each study in this thesis received clearance from the James Cook University Experimentation Ethics Review Committee (H4965).

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Abstract

Although there have been numerous studies completed on the seasonal variations in fitness in soccer players, majority of the literature has been on players in European and North American countries. Additionally, there is currently a lack of knowledge on the fitness of soccer players and their use of small-sided games (SSG) at the sub-elite and amateur levels of professionalism, particularly in Australia. Thus, the aim of the project was to investigate the physiological and performance changes that occur in Australian male and female soccer players in the tropics throughout the course of a competitive season. In addition, a secondary purpose of the project was to determine those factors that may influence the outcome including injuries, training component structure and attendance.

The investigation took place over the course of three separate seasons and focused on both adult and youth players within Far North Queensland (FNQ). The first year in 2013 was an observational season where fitness, attendance, training structure and injury data were collected on three sub-elite teams throughout the course of the competitive season. These data were again collected throughout an intervention year in 2014. In 2015, an intervention was again implemented however there was the addition of pre-season data collected.

In 2013, observational data was collected on fitness changes, training design, attendance and injuries in youth male and female players and male adult players. Seasonal variations in fitness were determined via the collection of fitness data at three points throughout the season (pre- and post-season). Tests that were completed were anthropometric measures (height, weight and body fat percentage), sit and reach (S&R), vertical jump (VJ), overhead throw (OHT), 505 agility both with and without the ball, 40 metre sprint both with and without the ball, multistage fitness test (MSFT) and Level 1 YoYo Intermittent Recovery Test (YYIR1).

During the observational season in 2013, VJ significantly decreased from pre- to post-season in females however the males showed no change. The observational year also demonstrated that there was a lack of compliance from the players to the training sessions that were implemented. There were similar attendance rates between both genders however the training session of the male team was structured to allocate 41% of time to conditioning whereas the females performed no conditioning training. Majority of injuries in both teams were during the first half of games and occurred in the lower body with more injuries

occurring during training time than in matches. Analysis of these data established that a strength and conditioning (S&C) intervention was needed to be implemented during the following season and as such, a soccer specific S&C program was introduced in the male adult team during the competitive season of 2014. This S&C program included use of the FIFA 11+ with the aim of targeting the strength, balance and proprioception elements found within the game of soccer as well as maximal aerobic speed training (MAS). It was found that this program produced minimal improvements in fitness throughout the year with only body fat percentage improving.. Training structure improved with the intervention following the incorporation of conditioning training without the ball increasing the time allocation to it from zero to 8%. The intervention also proved successful in improving the teams overall performance with more wins and a better goal difference at the completion of the season reported. The minimal improvements in the fitness results however, were suggested to be due to a lack of compliance to the program by the coach and the players and the fact that the program was only implemented during the competitive season leaving the potential for players to enter the competition with less than optimal fitness, thus increasing injury risks. Although the total number of injuries increased following the intervention, there was a significant decrease in the severity of injuries, particularly in the lower extremities. The total number of days lost due to injury also decreased following the intervention. However, in contrast to the results seen in the youth players, majority of the injuries in both years in the adult team occurred during games rather than training. Therefore, in 2015, a soccer specific S&C program was implemented during both the pre-season and competitive season in an attempt to rectify the lack of improvements in the previous season. In addition, another amateur club was utilized during this 2015 season in an attempt to address the compliance problems seen in the previous years and to investigate the effect of the program at a lower level of competition. The intervention program was completed two times per week for the entirety of the intervention and again included both the FIFA 11+ program and MAS training. During this season, the training sessions also focused on conditioning without the ball 18% of the time allowing for the intervention to be implemented as successfully as possible within the coach’s restrictions. However, compliance again was a problem with only two players completing the intervention and all testing sessions. Both players who followed the intervention improved in majority of the fitness variables and did not report any injuries.

Overall, the three investigative years demonstrated that there is a lack of education and knowledge by both coaches and players at the sub-elite and amateur levels of soccer in FNQ about what S&C is, and why it is so crucial in player development and success during the season.

Conclusions: Although there were minimal improvements in seasonal fitness in the sub-elite and amateur players following a soccer specific S&C program, the current investigation has shown that the intervention can decrease the severity of injuries. The investigation also demonstrated that a number of considerations must be taken by the S&C coach when working with players at this level of competition. Thus, there are several conclusions that can be drawn from the findings along with recommendations for both sports and S&C coaches to use when implementing periodization programs and training sessions:

1. Soccer training sessions should be designed and periodised to include both SSG and soccer specific S&C training incorporating the Federation Internationale de Football Association (FIFA) 11+ exercises for injury prevention;
2. The soccer specific S&C program should be introduced at the beginning of the pre-season period and continue throughout the duration of the competitive season. This will allow for familiarization and maintenance of the program during the season. Players should also be encouraged to complete the program during the off-season to ensure fitness is at least maintained between seasons;
3. It is recommended that teams complete the soccer specific S&C program at the beginning of a training session whilst players have minimal fatigue. This will increase compliance levels and better execution of the exercises;
4. Soccer specific S&C programs such as that utilized within this investigation may also assist in providing alternative training sessions for those players who cannot make the regular times or need additional support. Due to the minimal equipment needed for the completion of these types of programs, players can easily perform them at home in their own time;
5. It is recommended that S&C coaches attempt to educate sub-elite and amateur coaches and players on the importance of S&C when required. This education should focus on demonstrating the S&C coaches knowledge, experience and what they can bring to the preparation of the athletes;

6. This investigation demonstrated the need for sport and S&C coaches to consider the differences in players such as gender, age and competition level. Additionally, coaches must also consider the skill level of their players, especially if planning on utilizing SSG training within sessions. This is particularly important when SSG are going to be the sole form of training as if players do not possess the skills to perform the games at a high enough intensity, the fitness will not be improved as required.

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List of Abbreviations

7SAT	7 Stage Abdominal Test
ACL	Anterior Cruciate Ligament
BF	Body Fat Percentage
BMI	Body Mass Index
CMJ	Countermovement Jump
COD	Change-Of-Direction Ability
FNQ	Far North Queensland
FIFA	Federation Internationale de Football Association
MAS	Maximal Aerobic Speed
MSFT	Multistage Fitness Test
NCAA	National Collegiate Athletic Association
OHT	Overhead Throw
RPE	Rating of Perceived Exertion
RSA	Repeated-Sprint Ability
RSTs	Repeated Sprint Tests
S&C	Strength and Conditioning
S&R	Sit and Reach
SSG	Small Sided Games
TL	Training Load
UEFA	Union of European Football Associations
VJ	Vertical Jump
VO_{2max}	Maximal Aerobic Power
WAnT	Wingate Anaerobic Test

YYIR1	Level 1 Yo-Yo Intermittent Recovery Test
YYIR2	Level 2 Yo-Yo Intermittent Recovery Test

1. Introduction

1.1 Background

Soccer is the world's most popular sport being played in every nation with approximately 200 million people participating worldwide (Sporis, Jukic, Ostojic and Milanovic, 2009; Stubbe, et al., 2014). Soccer at the elite level is considered to be a complex sport requiring good physical abilities and cognitive attributes (Wong, Hejelde, Cheng & Ngo, 2015). A successful performance in the game demands all aspects of physical fitness, technique and psychological factors to be exceptional in addition to performing well in team tactics and game play (Arnason, 2003; Manzi, Bovenzi, Impellizzeri, Carminati and Castagna, 2013).

Importantly, players must undergo some form of fitness training such as strength or aerobic training or a combination of both in order to increase their chances of success. For example, recent methods of fitness training that are being utilized include small-sided games (SSG) and interval training (Caldwell & Peters, 2009). For training to be designed successfully, the common technique of periodization is often used as a framework, which allows systematical planning that directs physiological adaptations. This technique in conjunction with training aims to peak the athletes at a specific point during the season such as a race or grand final (Gamble, 2006). Team sports such as soccer often use this method of periodization to encourage their players to be optimally fit throughout the season and in preparations for finals. Ideally, this technique aims to improve the level of physical conditioning of the players whilst allowing them to perform at an adequate level during games throughout the season (Reilly, Bangsbo & Hughes, 2000). Although seasonal variations in fitness and the utilization of periodization has been the focus of a number of previous studies, these have been carried out on professional male players, generally in regions of Europe and North America (Caldwell & Peters, 2009; Engström, Johansson, Törnkvist, 1991).

In contrast, there has been minimal research on their youth and female counterparts, particularly at the sub-elite and amateur levels of competition (Caldwell & Peters, 2009; Engström, Johansson & Törnkvist, 1991). Specifically, there have been no research studies on those players within Australia which is an important aspect given that the tropics in winter within the Pacific region is vastly different to those winter conditions often used for soccer overseas.

As the majority of the research has been on males in the aforementioned regions, it is not appropriate to draw similar conclusions on those players within other countries including female and youth players. This is due to the number of differences that exist between players of differing genders, ages and competition levels. For example, there are existing variations in anatomical make up between males and females and the injury outcomes often differ between them (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). Furthermore, there are differences in the nature of game play of males and females with elite men having a work to rest ratio of 1:12 compared to 1:13 for their female counterparts (Arnason, 2004; Bangsbo, Nørregaard & Thorsoe, 1991; Gabbet & Mulvey, 2008). Junior players work at a ratio of 1:15 with a slightly slower game pace. Males also perform more jogging and less walking and standing during game time than females (Arnason, 2004; Bangsbo, Nørregaard & Thorsoe, 1991; Gabbet & Mulvey, 2008). Therefore, it is not appropriate to utilize existing conclusions to tailor training programs and periodization plans for players within Australia and particularly those female and youth players at amateur levels of competition. Thus, there is a need for research on the seasonal variations in fitness in Australian soccer players at the sub-elite and amateur levels including female and youth players.

Additionally, a player's ability to perform may also be influenced by factors that develop throughout the season including training session design, training session and game attendance and injuries (Arnason, 2004; Impellizzeri, Rampinini, Coutts, Sassi & Marcora, 2004).

As previously mentioned, soccer requires players to adequately establish a number of fitness attributes in order to be successful at the game. However, technical and tactical skills are also of a high importance as these elements play a large role in game performance as generally the teams that have the most possession of the ball, have more success (Lago-Peñas & Dellal, 2010). Therefore, as the aim of games is generally to win, research shows that soccer coaches often place a higher level of significance on training these technical and tactical skills rather than the fitness of their players, particularly at the sub-elite and amateur levels of competition (Lago-Peñas & Dellal, 2010). Often, this results in coaches utilizing SSG training as the main type of training as they have a high focus on these skilled elements whilst still working on improving fitness to some extent (Dellal, Hill-Haasm Lago-Penas, 2010). Additionally, as players have been reported to enjoy SSG training more than traditional conditioning training such as interval training, it is common at all levels of competition, particularly at the amateur levels where interest is a key factor as opposed to financial incentives (Los Arcos, et al., 2015). Coaches also find that this SSG approach of training presents a training situation that is especially motivating for players thus increasing its popularity (Los Arcos, et al., 2015).

Although this method of training is not a problem at the professional levels of competition as players often train at least five times per week and also undertake specific fitness conditioning, it can create issues at the amateur levels where players may only train one to three times a week and may not have the opportunity to train for fitness (Bunc & Psotta, 2001). It has been stated previously that SSG may not be an ideal training situation for all playing levels as the physiological responses to this type of training is highly dependent on skill and level of competition (Dellal, Varliette, Owen, Chirico & Pialoux, 2012). Furthermore, depending on pitch size and number of players, SSG may offer some similarities to maximal aerobic speed training, which is considered important in soccer, there are conflicting conclusions about whether SSG limit the ability to practice repeat changes of direction (Dellal, Varliette, Owen, Chirico & Pialoux, 2012; Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). Due to the number of variations that can exist in how SSG training is designed such as the number of players involved, size of the pitch and number of touches allowed on the ball, it is also questioned as to how effective SSG can be in increasing fitness should the coach not design the session appropriately. Coaches are often advised to design these sessions based on the level of skill in their players. However, as majority of literature has been conducted on players in Europe and North America, there needs to be discretion and understanding of the differences in competition levels between these overseas regions and Australia.

To date, there has been some research conducted on SSG training in Australian players, however these were completed in southern regions of Australia where the level of competition is of a much higher standard than northern regions such as Far North Queensland (Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Rowsell, 2010). Additionally, these studies also focused on elite level players such as those in professional sporting teams or sporting institutes and academies (Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Rowsell, 2010). Thus, more research is needed to examine the utilization of SSG training in Australian athletes, particularly at the sub-elite and amateur level. Such an investigation would provide further information as to whether this method of training is appropriate for these levels of competition or if it should be used in conjunction with a sport specific conditioning program to induce adequate levels of fitness during the competitive season.

Training session design can also have a big impact on the fitness of players throughout a season. As the season progresses, there are often changes in the way that performance sessions are designed with the need for them to include both game performance and injury prevention strategies as well as the fitness training focused on during pre-season. Thus, as the season advances, less time is allocated to fitness training.

As previously mentioned, there are a number of physiological elements that are required for success in soccer such as strength, power, agility and importantly, running performance (Buccheit, Mendez-Villanueva, Simpson & Bourdon, 2010; Dellal, Varliette, Owen, Chirico & Pialoux, 2012). In addition to improving these elements of fitness, training sessions may also aim to aid in injury prevention by strengthening the body and working on player weaknesses that may lead to injury susceptibility such as lacks in balance and muscle control in the lower extremities. Although injuries can cause large financial losses at the professional level of soccer such as in the English Premiere League, the amateur level presents a different need for injury prevention in that should it be successful, players are able to attend more training sessions and play more games (Krist, van Bijsterveldt, Backx & de Wit, 2013). This point is particularly important at this level of competition, as there are generally no players that can replace those who are injured. In previous years, soccer specific injury prevention programs have been developed to specifically aid in injury prevention via improvements in stability, co-ordination, flexibility and muscle strength (Krist, van Bijsterveldt, Backx & de Wit, 2013). One such program is the FIFA 11+ program, which is a structured program that consists of 11 exercises focusing on the previously mentioned variables. The efficacy of the program has been investigated previously in a number of countries and for the most part, had been found to be successful in reducing the rate and severity of injuries (Junge & Dvorak, 2004; Soligard et al., 2008; Steffen et al., 2013; Walden et al., 2012;). For example, Soligard et al. (2008) concluded that the Norwegian players who performed the FIFA 11+ program reported a 32% reduction in injury rates. Similarly, Steffen et al. (2013) reported that there was a significant reduction in injuries of 72%. However, although there are a lot of positive results that have come from investigating the use of the FIFA 11+ program, the majority of these studies have been in European and North American countries with no research having been conducted within Australia to the author's knowledge. Due to the differences in competition levels between overseas countries and Australia, it would be useful to investigate the potential effects of the FIFA 11+ program on Australian players, particularly at the sub-elite and amateur levels. An investigation such as this would aid in the determination of whether coaches and players at these levels of competition could utilize such a program successfully to reduce the risk of injuries and consequently, increase attendance rates at training sessions and games.

1.2 Statement of the Problem

To date, there have been numerous studies on the seasonal variations in fitness of elite soccer players in European and North American countries. However, there has been limited research conducted on the seasonal variations in fitness of sub-elite and amateur players, particularly in Australia. Additionally, research has focused mainly on male and adult players with minimal investigation completed on female and youth players. Subsequently, the changes in fitness that occur during a competitive season are relatively unknown in any players that are not elite European or American players.

Furthermore, the studies that have investigated seasonal variations in fitness in soccer players have only focused on the physiological fitness change aspects during the season. It has been reported that injuries have been shown to have an influence on fitness in prior levels of competition. Additionally, there has also been evidence that using a strength and conditioning (S&C) injury prevention program can reduce the number and severity of injuries (Silvers-Granelli, et al., 2015). However, although these previous findings provide insight into seasonal variations in fitness and why they may occur, literature has not yet explored factors such as training session structure and game and training session attendance. Currently no research exists on whether injuries have the potential to influence changes in fitness in amateur players in Australia.

Furthermore, there is also a lack of research on whether the implementation of a S&C injury prevention program may assist in improving these changes.

This thesis investigates the fitness variations in Australian sub-elite and amateur players during a season and assists in the identification of those factors that contribute to the findings. Secondly, this investigation will analyse the effect of a soccer specific S&C program on fitness and injury prevention. Thus, the conclusions will provide assistance for amateur coaches and players within Australia in developing and implementing periodised training throughout the seasons to maximize training adaptations and performance.

1.3 Aims of the Project

The project was separated into three studies with the following aims:

To investigate the effect of,

1. SSG soccer conditioning training practices on seasonal fitness in sub-elite youth male and female and sub-elite and amateur adult male soccer players,
2. The effects of an in-season S&C intervention on seasonal fitness of sub-elite male soccer players, and
3. The effects of a pre-season and in-season S&C intervention on seasonal fitness of amateur male soccer players, and
4. Determine those factors that may influence the outcomes including;
    a. Type of training and time spent on each type of training,
    b. Game and training session attendance by players, and
    c. Injuries and if injuries become an issue, determine the common types, severity and frequency of them.

1.4 Hypotheses

For each of the above studies it was hypothesized that:

1. The use of SSG training practices would have an effect on seasonal fitness in sub-elite youth male and female and sub-elite and amateur adult male soccer players.
2. The inclusion of a soccer specific S&C intervention during the season (2014) would result in an increase in fitness compared to the previous year (2013) where no S&C intervention was undertaken.
3. The inclusion of a soccer specific S&C intervention during the pre-season and competitive season (2015) would result in an increase in fitness in comparison to the previous year (2014) where no pre-season S&C training would be undertaken.
4. The effects on fitness would be associated to factors such as the type of training and the time spent on each type of training, player attendances at training sessions and games and injuries.

1.5 Significance of the Study

The series of studies will improve our knowledge and understanding of seasonal variations in fitness in soccer players at both the sub-elite and amateur level in Australia and particularly Far North Queensland. Together, the studies will allow for advancement in understanding of how sub-elite and amateur level players training can have an impact on their changes in fitness throughout a competitive season. In addition, the studies will provide information on how injuries can influence fitness both directly and indirectly via impact on attendance levels at games and training sessions.

Chapter 3 discusses the impact of SSG training on physiological and functional fitness in sub-elite male and female youth soccer players. Chapter 4 then examines how differing ages and gender can also have different fitness, training, attendance and injury outcomes and offers conclusions and recommendations on how to address players of different characteristics. Chapter 5 discusses the effect of soccer specific conditioning on injury rates and whether this type of training can assist in preventing common injuries in sub-elite players. Chapter 6 then builds on Chapter 5 by discussing the effects of the soccer specific conditioning program on seasonal fitness in sub-elite players. Chapter 7 then offers a comparison of these factors in players at different levels of competition (sub-elite vs. amateur). Chapter 8 complements the findings of the studies and previous chapters by providing recommendations on how to implement education for coaches and players at the sub-elite and amateur levels of soccer. Furthermore, Chapter 9 aims to provide overall conclusions on how a S&C intervention can provide necessary improvements within these amateur players with a specific focus on how they can assist in injury reduction and improvements in attendance.

Collectively, the findings from the three studies will provide further knowledge for coaches to make required adjustments to how training sessions are structured to allow for players to optimize training and ultimately sporting performance. By furthering education, coaches will also be able to understand the importance of sport science and S&C and how it may improve player's performance both in physiological fitness and injury prevention. These findings may also be of assistance to those teams from developing countries preparing for the FIFA World Cup in Qatar in 2022. Those countries that have less access to top facilities, equipment and coaching staff may find value in what the chapters within this thesis have to offer.

1.6 Delimitations

The included studies were delimited to:

1. Australian sub-elite youth male and female, sub-elite male and amateur male soccer players. Thus, whilst the results may represent the abovementioned population groups, the extrapolation of the results to other population groups such as adult female or elite soccer players or other sports may not be appropriate.
2. Field based S&C intervention exercises. The exercises selected for the conditioning component of these studies was based on the limited resources available to the teams on the field. Therefore, the extrapolation of the findings to

other S&C exercises (e.g. Gym or laboratory based exercises) may not be appropriate.

1.7 Limitations

The findings of the included studies were limited as:

1. The players were not a random sample of the playing population as the teams utilized within the studies were the selected representative teams of the Far North Queensland region and thus the players included were selected prior to commencement of the investigation; and
2. Sample size was limited due to the need to conduct all conditioning sessions and training of teams at the same time. Therefore, the intervention studies were limited to one team at a time. However, more than one team was investigated when possible such as during the observational year; and
3. Controlling for technical and biological variability. All efforts were made to control for such variability by regular calibration of equipment, conducting the tests at the same time of the day on the same day for each testing session and requesting players to wear the same shoes (i.e., soccer cleats) for each testing session.

1.8 Format of the thesis

The thesis is formatted as outlined below:

- Chapter 1 offers a brief overview of seasonal fitness in soccer and the general changes that are found in team sports
- Chapter 2 reviews previous literature on seasonal variations in fitness and provides a deeper analysis on the general trends in soccer players. Additionally, it discusses the implicating factors that may potentially influence seasonal fitness including training session structure, attendance and injuries
- Chapter 3 investigates the impact SSG training can have on seasonal variations in fitness in sub-elite female soccer players

- Chapter 4 compares the seasonal variations in physiological and functional fitness of sub-elite youth male and female soccer players
- Chapter 5 discusses the differences in seasonal variations in fitness between sub-elite male and female youth players by analyzing the fitness, training components, attendance and injuries of players throughout the competitive season
- Chapter 6 explores the effect of a soccer specific conditioning program on injury rates in sub-elite males
- Chapter 7 provides a comparison of the seasonal variations in fitness of sub-elite male soccer players with and without a S&C intervention
- Chapter 8 provides a case study focusing on the implementation of a S&C intervention in amateur soccer players
- Chapter 9 discusses overall conclusions on the important considerations that arise when working with amateur sporting teams such as those aforementioned in previous chapters.
- Chapter 10 provides an overall conclusion of Chapters 1 through 8 and provides both practical applications and recommendations for future studies.

Chapter 3 was written as a book chapter and has subsequently been published. Chapter 4 was published in a journal. Chapters 5, 6 and 7 have been written as journal articles and were currently under review at time of submission of this thesis. Chapter 8 was written as a case study due to the low compliance rates during the season and provides further reasoning as to why sub-elite and amateur players may not increase fitness during the season. Chapter 9 was then written as a discussion article for publication and was in press at the time of the submission of this thesis.

The studies that were the basis for Chapters 3, 4, 5, 6, 7 and 8 were designed to progress from one study to the following study. For clarification, a brief paragraph has been included prior to for all chapters for explanation on how previous findings and conclusions have constructed the following study.

2: Seasonal Fitness in Sport

The following Literature Review is divided into three sections and is structured to allow for a broad understanding on the topic before discussing individual components specifically. The first section provides an overall look at the big picture behind the physiological attributes required within the game of soccer and the differences that exist between players of differing characteristics. The second section discusses previous literature's findings on seasonal fitness changes that have occurred in a number of sports with a focus on soccer in particular. Additionally, the reason as to why certain changes or lack thereof may occur throughout the season will also be examined. Finally, the third section will take an in depth look at the mechanisms behind these results such as the use of SSG for training, attendance and injuries.

2.1 Physiological Attributes of Soccer

To understand seasonal fitness within the game of soccer, it is important to first establish the physiological attributes that are required within the game to appreciate how the players must perform physically to be successful. It is essential for players functioning at the professional level of soccer to have a high-level of overall physical fitness (Sporis, Jukic, Ostojic & Milanovic, 2009 & Bangsbo, Mohr & Krustrup, 2005). Fitness variables such as anthropometric measures including height, weight and body fat percentage, endurance and aerobic and anaerobic power are all important when evaluating soccer players at the elite level. Although soccer is considered to be a predominately aerobic game, there is the need of a balance between aerobic and anaerobic variables for the player to be successful (Sporis, Jukic, Ostojic & Milanovic, 2009). However, in situations where players are matched for aerobic capacity, additional match-related fitness skills such as sprinting and jumping technique can be the difference between winning and losing the ball and are thus, desirable by soccer players (Clark, 2008).

The capacity for a soccer player to not only acquire, but also maintain a good level of physiological fitness throughout the competitive season is important in determining success (Caldwell, 2009). In soccer, the competitive season is generally eight to nine months long and although teams may aim to have all players at peak fitness throughout the season, it can become difficult for players to maintain this optimal level of fitness continuously due to a number of reasons, including physiological stress (Casajus, 2001).

Physiological stress factors such oxidative and functional stress (Bangsbo, Mohr & Krustrup, 2006), and hormonal and immune system imbalances (Silva, Magalhaes, Ascensao, Oliveira, Seabra & Rebeo, 2011) can make the maintenance of player's fitness a more complex process due to placing players under prolonged physiological stress. In conditions such as these, the ability for a players performance to either be maintained or improved is not only impacted by appropriate conditioning, but also by how well the body systems can regenerate and recover following stress from multiple stimuli (Silva, et al., 2011). It is therefore important for coaches to understand the balance required between training stimuli to improve performance and the need for recovery from the physiological stress. Too much or too little of either will result in an imbalance and a deterioration in player health and fitness. Thus, it is essential that coaches appreciate what each soccer specific physical component involves in order to train the fitness of players appropriately.

Aerobic conditioning is considered to be an important component of fitness in soccer players for a number of reasons. A high maximal aerobic power output has been correlated with the work to rest ratio that is involved in soccer and thus it is required within the game. A good aerobic capacity also aids in the recovery from high-intensity intermittent exercise found in soccer. The importance of this is highlighted by the good aerobic capacity and team ranking in a number of different levels of competition (Impellizzeri, et al, 2005). Overall, to be successful as a soccer player, it is essential that aerobic capacity be at maximal levels throughout the season.

The level at which aerobic capacity is regarded as maximal is deemed to have a mean intensity of approximately 80% of maximal aerobic power (VO_{2max}) (Stølen et al., 2005). This figure also represents the typical values of aerobic capacity that professional players possess (Edwards, Clark & Macfadyen, 2003). This aerobic threshold is considered to be important as the association between distance covered during a match and VO_{2max} has been utilized to suggest the metabolic pathway that is predominantly used during professional soccer is aerobic (Bangsbo, 1993).

Although soccer is considered to be an intermittent sport in which players often perform low-intensity activities for approximately 70% of the game, the heart rate and body temperature measurements that can occur during a game suggest that the game's required total energy demand is high (Bangsbo, Mohr & Krustrup, 2006). As an elite player can perform 150-250 short but intense actions during a game, it is clearly evident why this high level of energy is needed (Maughan & Shirreffs, 2010). Consequently, games at the top level are characterized by repeated sprinting and high intensity activities such as intermittent jumping and landing interspersed with low intensity activities such as walking or standing (Bangsbo et al., 2006; Bloomfield, Polman, & O'Donoghue, 2007; Bradley et al., 2009; Krustrup et al., 2010; Terje, Ingebrigtsen, Ettema, Geir & Wisloff, 2015). These repeated sprints are generally characterized as being explosive short bursts of exercise followed by brief recovery periods throughout the 90 minutes of game play (Stølen et al., 2005). It is essential for players to have the ability to not only perform these repeated sprints, but to also recover from them, especially during the second half of a game when immense fatigue can arise (Wong, Hejelde, Ccheng & Ngo, 2015). Therefore, it is a requirement that both the aerobic and anaerobic energy systems are activated in order to fulfill the muscle energy demands required during a game (Meckel, Machnai & Eliakim, 2009).

It is essential that in addition to being able to perform sprints integrated with rest periods that players be able to demonstrate sport-specific fitness variables within a game including power, speed, flexibility and agility and also sport-specific activities such as rapid acceleration and deceleration, kicking, tackling, heading and dribbling the ball (Arnason, 2003; Caldwell, 2009; Terje, Ingebrigtsen, Ettema, Geir & Wisloff, 2015). Stolen, Chamari, Castagna and Wisloff (2005) state that during a 90 minute soccer match, players can perform some form of high intensity running approximately every 70 seconds, 10-20 sprints, 10 headings, 15 tackles, 30 passes and have 50 involvements with the ball (Stolen, Chamari, Castagna & Wisloff, 2005). Motion analysis studies of match play have suggested that approximately 96% of sprints during a game are less than 30 meters with the majority of all sprints performed being less than 10 meters (Bangsbo, 1993; Clark, 2008; Reilly and Thomas, 1976).

Repeated-sprint ability (RSA) and change-of-direction ability (COD) are two of the other most important physical requirements in the game of soccer due to the significant amount of multi-directional change of movements and sprints that have been reported at the elite level. These two variables have been shown to be useful in talent identification, differentiating between players at different levels and also a great training mechanism during weekly sessions (Wong, Hejelde, Ccheng & Ngo, 2015). Terje, Ingebrigtsen, Ettema, Geir and Wisloff (2015) also concluded a novel finding in that acceleration and deceleration contribute 7-10% and 5-7% of total player load throughout a game respectively. Therefore, it is essential that in addition to common fitness variables such as speed, power and agility, accelerations and decelerations per game need to also be measured to obtain a "true workload". It is also important to consider that throughout a game players will also change pace and sustain forceful contractions to control the ball and maintain balance against defensive players (Stolen, Chamari, Castagna & Wisloff, 2005) so it is also essential that they maintain optimal strength and balance throughout a season.

Interestingly, the average player will only have contact with the ball for 2% of the total game time (Foran, 2001). However, a player who develops and increases their movement skills will have a better chance of winning the ball and thus, increase that percentage. The movement skills required often depend on the position the individual is playing. For example, the goalkeeper will need to be work hard on maintaining a strong stance, improving reaction skills from all positions and cross over steps which may be linked to a number of moves including jumping, landing and diving. By improving their base stance, the goalkeeper will have the best opportunity to react in every direction. Similarly, players in the full back position are also required work on a strong base but it must be in both the lateral and forward directions in order to react to the offensive player. They must also have good acceleration and deceleration as well as good lower body power to assist in vertical jumping when competing to win the ball in the air (Foran, 2001). In contrast, players in the front line such as strikers and wingers must concentrate on linking a number of skills together as they cover greater ground than those in other positions and must be able to transition quickly once they have lost the ball. These attacking players should also focus on absolute speed (Foran, 2001). It has been suggested that players in wider and attacking positions sprint longer distances compared to those in more central positions due to a number of reasons. For example, they have more space to reach maximal sprinting velocity compared to their central counterparts who have a lack of space due to the number of surrounding players (Varley & Aughey, 2013). The playing style of wider players also differs to central players in that there is an emphasis on the need to participate in both offensive and defensive phases during a match and therefore, wider players are likely to have an elevated number of sprints during the 90 minutes of gameplay (Di Salvo, Baron, GonzALez-Haro, Gormasz, Pigozzi & Bachl, 2010).

Aside from differences in positional roles, there are also numerous differences between both male and female players as well as adult and adolescent groups, meaning direct comparisons cannot be made between genders regarding the physiological requirements needed within soccer. Various differences including anatomical variances, social, mental and emotional approaches to training and game attendance and the genetic and biological make-up of bodies make it difficult to compare players of opposing groups. Difference's in the nature of the way the game is played exists between males and females as well as juniors and seniors. Elite male soccer players have a work to rest ratio of 1:12 compared to 1:13 for their female counterparts. Junior players work at a slightly slower game pace with a ratio of 1:15. Male players are also known to perform less walking and standing and more jogging than females (Arnason, 2004; Bangsbo, Nørregaard & Thorsoe, 1991; Gabbet & Mulvey, 2008). Differences also exist in the distances individual players cover during a game with Di Salvo et al. (2007) reporting that 300 elite players who competed in the Spanish Premiere League and the Champions League reported covering distances ranging 5.7 to 13.7 km during a game. This vast difference in distances between individual players clearly indicates that not all players within the same league will cover the same distances. However, it is important to note that even when total distance covered is not high, soccer still requires great physical demand due to that fact that generally more than 600m of sprinting and 2.4km of running at a high intensity is performed within a single game (Maughan & Shirreffs, 2010). These differences between individuals, teams, gender and varying levels of competition mean that it is not always as simple as just designing training as a 'one size fits all' method. In order to encourage success, training must be designed and implemented in a way that addresses the individuality of the athletes by taking their needs into account (Chandler, 2002).

2.2 Differences in Physical Attributes Between Players

Past literature has focused on determining the differences and similarities in the fitness of soccer players at different levels of professionalism, between genders and also of players at different ages (Ingebrigtsen, Bendiksen, Bredsgaard Randers, Castagna, Krustrup & Holtermann, 2012; Manzi, Bovenzi, Impellizzeri, Carminati & Castagna, 2013; Mujika, Santisteban, Impellizzeri & Castagna, 2009). In order to distinguish the differences in how athletes need to train between the varying levels of competition, genders and ages, it is essential to determine how the different groups of athletes perform in regards to fitness and how their individual seasons are constructed.

2.2.1 Elite vs. Sub-Elite vs. Amateur Players

The match involvement that is attributed to seasonal volume is proportional to the competition level with premiership standard competition being much more demanding compared to lower-standard championships. Due to the high number of fixtures throughout a season, elite level players are set unique training and competitive demands which are of a much higher physical capacity than their sub-elite and amateur counterparts (Manzi, Bovenzi, Impellizzeri, Carminati & Castagna, 2013; Rampinini et al., 2009; Wong, Hejelde, Cheng & Ngo, 2015). Evidently, it could be suggested that professional players should have a higher level of fitness due to training and playing essentially ‘harder’ than those players at lower levels of professionalism. Indeed, Ingebrigtsen, Bendiksen, Bredsgaard Randers, Castagna, Krustrup and Holtermann (2012) demonstrated that performances by elite soccer players in the YYIR1 and the Level 2 version of the Yo-Yo Intermittent Recovery test (YYIR2) were much higher than that of sub-elite players. Additionally, elite players also recorded a lower heart rate after the two and four minute points of the YYIR2 (Ingebrigtsen, Bendiksen, Bredsgaard Randers, Castagna, Krustrup & Holtermann, 2012). In agreement, Wells, Edwards, Winter, Fysh and Drust (2012) concluded that male professional soccer players possess a superior aerobic capability in regards to high-intensity soccer activity when compared to their amateur counterparts. Interestingly, teams within the same division can also produce significantly different results with more successful teams performing better. For example, successful teams performed better at peak five minute high intensity running and sprinting distance during a match, as well as the YYIR2 test than their unsuccessful counterparts within the same league (Ingebrigtsen, Bendiksen, Bredsgaard Randers, Castagna, Krustrup & Holtermann, 2012). Meckel, Machnai and Eliakim (2009) concur stating that soccer players at the professional level tend to have a higher VO_{2max} than those at the recreational level and are therefore, inclined to cover more distance during a game due to the positive correlation between the two variables. In addition to performing better in aerobic capacities, top-level players have also been shown to have a better RSA and a better ability to sustain a higher number of high-intensity repeated sprints during a game than their lower level counterparts (Wong, Hejelde, Cheng & Ngo, 2015; Rampinini et al., 2009). Mohr et al. (2003) similarly reported that although top-level professional players cover only 5% more distance than their lower-level counterparts, they perform 28% more at a high-intensity level.

In contrast, not all literature is in agreement with numerous studies concluding that there are minimal or no differences in the fitness performances of elite, sub-elite and amateur players. For example, Bradley, Di Mascio, Peart, Olsen and Sheldon (2010) found there was no difference in the performance of high intensity running distance or the mean recovery time of running at maximal speed between international and elite domestic players. It has also previously been reported that there was no difference in the VO_{2max} between a group of English professional and amateur players with the teams reporting measures of 56.5±2.9 $mL.kg^{-1}.min^{-1}$ and 55.7±3.5 $mL.kg^{-1}.min^{-1}$ respectively (Wells, Edwards, Winter, Fysh & Drust, 2012). Similarities in total distance and high-intensity running distances during a game have been reported in elite domestic and international players (10859±980m vs. 10666±566m) suggesting that there may not be a significant difference in terms of tempo between levels as first thought (Bradley, Di Mascio, Peart, Olsen & Sheldon, 2010). However, the group of domestic players involved in the corresponding study also consisted of a number of elite international players, which may have accounted for the similarities reported between groups (Bradley, Di Mascio, Peart, Olsen & Sheldon, 2010). Additionally, it was reported that mean recovery time between bouts of high intensity running was 70±25 seconds irrespective of playing level while maximal running speed was also similar between levels (7.76±0.31 vs. 7.66±0.34 $m.^{s-1}$). These results suggest that there may not be differences in more than just aerobic variables (Bradley, Di Mascio, Peart, Olsen & Sheldon, 2010). Thus, the literature at present is not conclusive as to whether those male players at the higher level of professionalism are in fact ‘fitter’ than their sub-elite and amateur counterparts.

It is also suggested that when considering the differences between differing levels of competition, that gender also be taken into account. This is due to the fact that it has previously been concluded that the gap in the fitness requirements of soccer is much wider between levels in the female game than in the male game (Mujika, Santisteban, Impellizzeri & Castagna, 2009). Consequently, when working with females, it is important that this knowledge is incorporated into the decision making process of implementing training to avoid making the same assumptions between genders (Mujika, Santisteban, Impellizzeri & Castagna, 2009). These differences between genders will be discussed in further detail below.

2.2.2 Male vs. Female Players

In addition to differences between levels and ages of players, it has also been reported in previous literature that there are distinct differences in the performances of male soccer players when compared to their female counterparts. Mujika, Santisteban, Impellizzeri and Castagna (2009) concluded that senior and junior female soccer players only covered half or less than half of the distance covered by male soccer players in the YYIR1 test respectively. It has been suggested that these differences in performance between genders may be due to the much lower development of endurance often seen in female soccer players (Mujika, Santisteban, Impellizzeri & Castagna, 2009). Senior and junior male players have also been reported to perform approximately 34% and 55% higher than their female counterparts in a countermovement jump. Additionally, male players were found to be faster in a 15 metre sprint test and 15 metre agility test than female players at both the senior and junior levels suggesting this gender difference is not limited to just aerobic capacity (Mujika, Santisteban, Impellizzeri & Castagna, 2009).

Although differences have been reported between males and females in regards to physical performance, it is important to consider that gender needs to be taken into account before assumptions of future performance indicators are made. For example, although there are significant differences between senior male and female players, the differences were significantly higher between genders at the junior level (Mujika, Santisteban, Impellizzeri & Castagna, 2009). Stølen et al., (2005) for example, reported that the physiological demands such as percentages of maximum heart rate and maximum oxygen consumption imposed on elite players are similar in males and females. However, although the physiological demands may be similar between genders, it is important to take into account the demands of training sessions and competitive matches as this is often where differences can occur. It is known that elite male players generally cover 33% more distance at high intensity than their female counterparts (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). Thus, it is vital that coaches and teams that want to be successful, both select and train their players to cope with these physical stresses presented during training and game situations in an individualized manner to addresses the gender in accordance.

2.2.3 Senior vs. Junior Players

In recent years, the participation rate of children and adolescents in competitive sports has increased and in particular, soccer has become one of the most popular sports among the younger generations (Meckel, Macnai & Eliakim, 2009). However, just as with professionalism levels in adult players, it is important to understand how junior and youth players differ from their older counterparts. There are a number of considerations that need to be contemplated when discussing junior players such as the differences in varying fitness components to adult players and the way in which the seasons are constructed.

Research has reported that elite female senior soccer players (23.1±2.9 years) possess a significantly higher aerobic capacity than their junior counterparts (17.3±1.6 years) with the teams reaching 1224±255m and 826±160m in the YYIR1 test. This finding indicated that the activity pattern of senior play is somewhat different to that of junior play (Mujika, Santisteban, Impellizzeri & Castagna, 2009). However, it has also been shown that the typical pattern of activity in all levels of soccer including that involving children and adolescents is characterized by short bursts of sprints as opposed to longer sprints so it is evident that both anaerobic and aerobic fitness is important in the maintenance of fitness in soccer (Meckel, Macnai & Eliakim, 2009). In addition, irrespective of age it is evident that well developed anaerobic and aerobic fitness are both still important pre-requisites for success performance at the elite level in women's soccer (Mujika, Santisteban, Impellizzeri & Castagna, 2009).

Although it is well established that explosiveness and lower-body strength are essential for successful athletic performance, it is known that these variables increase with maturity (Secomb, et al., 2015). It has been reported that senior female soccer players at the elite level in Spanish league championships performed significantly better than their junior counterparts in both countermovement jump and a countermovement jump with an arm swing (Mujika, Santisteban, Impellizzeri & Castagna, 2009). Although there have been many reports of differing fitness performances between senior and junior players, it is also important to consider that occasionally these differences do not occur. For example, Mujika, Santisteban, Impellizzeri and Castagna (2009) reported that there were no differences in VJ or over 15 metres of ball dribbling between male senior and junior players in Spanish league clubs. Interestingly, when looking at female senior and junior levels, senior female soccer players performed the YYIR1 test at a level of 48% more than their junior counterparts. However, there was only a 15% difference found between senior and junior males (Mujika, Santisteban, Impellizzeri & Castagna, 2009).

In addition to contemplating the differences in fitness components in junior players, it is also important to consider the differences in season length and off-season period between junior and senior players. Impellizzeri, et al. (2006) states that the typical summer break ranges from two to three weeks for senior players whereas there is a much longer period for junior players. Senior elite clubs in Australia such as within the A-League typically play 27 games (not including finals) whilst junior clubs within regions such as Far North Queensland (FNQ) will only play approximately 16 games (A League, 2017). This high number of games during the competitive season for elite teams often leaves minimal time between the end of the season and the beginning of pre-season. This short intermission between seasons in the senior players can result in problems with recovery as oxidative enzyme levels cannot return to the pre-detraining levels (Impellizzeri, et al., 2006). It is therefore necessary to understand that youth players need to address how to best train these fitness qualities from a young age and then into adulthood whilst still considering season length and recovery time.

2.3 Seasonal Fitness

In order to train efficiently and ensure that an athlete is training productively, coaches often apply the technique of periodisation. Periodisation offers a framework for training to be systematically planned to specifically direct physiological adaptations towards a training goal (Gamble, 2006). By planning training to specifically target a goal, an athlete can develop a superior level of strength, power, body composition and numerous other performance variables (Gamble, 2006). The utilisation of both periodization and training is aimed at enabling the athlete to peak at a specific point during the season such as the grand final. Team sports such as soccer generally use this periodization technique to allow for their players to reach optimal fitness throughout a season and essentially, be at peak fitness at grand final time at the end of the season (Gamble, 2006).

The beginning of the season often presents numerous problems as most semi-professional or amateur teams do not undertake any off-season training and it has been shown that a short period of just eight weeks, detraining can occur in a number of fitness variables including aerobic fitness, sprint ability and anaerobic power (Caldwell & Peters, 2009). Players in this deconditioned state at the beginning of preseason training often have to work particularly hard to reach the often high level of fitness that is required for the start of the competitive season. Consequently, these players are also at a high risk of mental and physical fatigue throughout and towards the end of the season (Caldwell & Peters, 2009).

Training during the pre-season period generally focuses on rebuilding the players' fitness following the off-season. Traditionally, the pre-season is when the majority of athlete physical preparation occurs and this then enables them to fulfil the requirements of the season physiologically (Bangsbo, 1993). During this period it is generally accepted that although the specific goals of the training can vary, the physiological demands of the sessions are greater than any other point in the season (Svensson, 2007). A study by Jeong, Reilly, Morton, Bae and Drust (2011) demonstrated that a training program prescribed in the pre-season resulted in significant increases in the time spent in the highest intensity heart rate zone, mean heart rate and RPE training loads. The authors suggest that these increases in physiological stress mechanisms are due to the need for players to complete these sessions at a high intensity in preparation for the levels of fitness needed during the competitive season.

To develop fitness for the impending competitive season, pre-season training aims to increase the training load (TL) by 2-4 times more than in-season training to allow for these physiological improvements to take place. Programming during the pre-season period can be challenging for coaches as they are attempting to maximize positive physiological adaptations, whilst trying not to overload the players to avoid injuries and over training. Therefore, careful implementation, control of TL and measurements of how individuals respond to training is essential in order to maximize the adaptations that come with training (Buchheit, et al., 2013).

Pre-season training has also been reported by Jeong, Reilly, Morton, Bae & Drust (2011) to focus on technical and tactical sessions in an attempt to address the need for physiological conditioning via the use of the SSG approach. It has also been stated that the highest rate of injuries can occur during the pre-season period and that it is during this time that the greatest changes in physical fitness can occur (Gabbett, 2004). This method is often supported by literature due to the sport specific approach in training fitness (Köklu, Aşci, Koçak, Alemdaroĝlu & Dündar, 2011; Little & Williams, 2006).

In contrast to the “pre-season”, “in-season” training focuses on maintaining the fitness gained during the “pre-season” period (Reilly, 2007). The intention of training throughout a season is to not only improve but also maintain the level of physical conditioning that is required to perform at an adequate and successful level during games (Reilly, Bangsbo & Hughes, 2000). However, previous literature suggests that in-season training is less intense compared to pre-season training due to the fitness already gained during the latter period (Jeong, Reilly, Morton, Bae & Drust, 2011). The programming of weekly training sessions for soccer players varies throughout the season according to the coaches experience, annual plan and the number of fixture games (Bangsbo, Mohr & Krustrup, 2006; Impellizzeri, et al., 2006).

It is also important to consider the differences that levels of professionalism can present in training considerations such as session frequency, duration, volume and intensity. Elite soccer players for example, generally participate in training and/or games three to four times per week, four to six times per week (Bangsbo, Mohr & Krustrup, 2006;

Bunc & Psotta, 2001) or even as high as one to two times per day, five days a week (Impellizzeri, et al., 2006) depending on the team's level of professionalism. Thus, it can be seen that soccer players at this level undertake a substantial amount of training. In contrast, players at the lower levels of sub-elite and amateur sport train substantially less with the general consensus being that there is a maximum of three to four trainings a week for amateur teams (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011).

Performance in the majority of sports is a result of a combination of several factors such as the genetic endowment, health status and training of the athlete (Svensson & Drust, 2005). These variables are often analysed by the coach or a sports scientist throughout the season to provide individual profile feedback to the players and the results can also be used for the development of training strategies (Svensson & Drust, 2005). Fitness testing throughout a competitive season in particular is considered to be of great importance due to a number of reasons (Taylor, Portas, Wright, Hurst & Weston, 2012). Testing identifies both the strengths and weaknesses of sporting teams as well as individuals (Gravina, Gil, Ruiz, Zubero, Gil & Irazusta, 2008; Sporis, Jukic, Ostojic & Milanovic, 2009; Svensson & Drust, 2005) and also helps to keep a record of how an athlete's fitness changes throughout a season (Gravina, Gil, Ruiz, Zubero, Gil & Irazusta, 2008). Testing also allows for the determination of the effectiveness of a training program and consequently, allows for coaches to alter a program to focus on the relevant strengths and weaknesses that have been identified (Sayers, Sayers & Binkley, 2008; Sporis, Jukic, Ostojic & Milanovic, 2009). Finally, frequent fitness tests play a role in a comprehensive needs analysis that ensures training session design is adequate in encouraging players to meet sport specific tasks and goals throughout a season (Jalilvand, 2015).

Regular fitness testing to evaluate soccer player's fitness is essential as teams should be able to compete successfully throughout an entire season which may encompass 10-11 months of the year (Silva, et al., 2011). Successful testing requires coaches to implement the tests in the most efficient manner possible by ensuring reliability, validity and sufficient recovery times are employed (Sayers, Sayers & Binkley, 2008). Correct timing of testing is also highly important and it is suggested that testing be implemented within two days of the respective time point beginning (eg. within two days of pre-season period) (Sayers, Sayers & Binkley, 2008). It is essential that the players complete the same battery of tests at each time point during the season to allow for consistency and also familiarization (Sayers, Sayers & Binkley, 2008). The time points at which players perform testing can vary depending on the needs of the coaches and players but are most commonly implemented at pre- and post-season. Players are often tested at the beginning of pre-season for three primary reasons a) to allow the coach to design an appropriate seasonal program b) to assess the current physical attributes of players and c) to identify which players completed the set program given to them during the off-season (if applicable) (Sayers, Sayers & Binkley, 2008).

The order in which the tests are performed is also deemed to be important when designing a battery of tests as not only is it vital to consider that different tests tax different energy systems, but it is also essential to allow sufficient rest periods (Sayers, Sayers & Binkley, 2008). In addition, depending on the variability of the testing, athletes may be required to travel between locations for different tests so this must also be considered when designing the test order. Once the order of the tests have been decided, it is encouraged that the test order remain the same whenever completed during the season (Sayers, Sayers & Binkley, 2008).

Lastly, in order to be effective, it is crucial that the appropriate tests are selected based on not only the sport, but also on the characteristics of the individual's participating including age and gender (Meckel, Machnai & Eliakim, 2009). Although there are many laboratory-based tests that exist that are soccer specific such as the VO_{2max} test (used to measure maximal oxygen uptake) because as soccer is a field based sport it is suggested that this be an important factor in the decision process of which tests are appropriate. As laboratory based tests often require the use of expensive equipment, field tests are often deemed as being easier to implement. Field tests are also concluded to be more specific to actual soccer performance as although laboratory tests provide information on the body's response to specific activities within a controlled environment, the results may not replicate the performance during a soccer game (Sayers, Sayers & Binkley, 2008).

2.3.1 Aerobic Capacity

The YYIR1 Test has been deemed a sensitive and appropriate tool to detect changes in the seasonal fitness of soccer players (Bangsbo, Iaia & Krustrup, 2008; Sayers, Sayers

& Binkley, 2008). The YYIR1 and YYIR2 are among the most applied tests in soccer to evaluate a player's aerobic performance. The tests are used to determine a player's ability to intermittently recover and perform exercise (Bangsbo, Iaia & Krustrup, 2008) and it has been emphasized that as it has been found to correlate with distance covered in a match, and consequently helps to assess for match fitness and performance (Mohr, Krustrup, Andersson, Kirkendal & Bangsbo, 2008; Rampinini, et al., 2007). Additionally, the YYIR1 and YYIR2 are also related to the amount of high-intensity activity that a player completes during a game (Ferrari Bravo, et al., 2007) due to their replication of the taxing of both the phosphagen and glycolytic energy systems (Sayers, Sayers & Binkley, 2008).

Both the YYIR1 and YYIR2 consist of 20-meter shuttle runs with speed progressively increasing with a 10 second active rest period in between every two shuttles. Players are to continue with the test until they are unable to keep up with the required test speed (Krustrup et al., 2006). With each version of the test requiring minimal equipment and understanding, both are practical to use when evaluating a player's ability (Bangsbo et al., 2008). Coaches also often use the YYIR1 and YYIR2 as research has deemed them to be valid and reliable whilst still showing high sensitivity and thus, the test allows for analysis of athletes' physical capacity (particularly in team sports) (Sayers, Sayers & Binkley, 2008).

2.3.2 Strength and Power

Sayers, Sayers & Binkler (2008) state that as strength and power are defined as "the maximum amount of force that a muscle or muscle group can generate" and "the ability of a muscle to exert high force while contracting at a high speed" respectively, it is appropriate to test for these components separately (pp. 72). Maximum lower body muscular power (also known as anaerobic power) can be tested through a variety of body weight jumps including a VJ. A VJ test has been deemed appropriate to test for power in soccer as there is a close relationship between the jump, and soccer performance (Sayers, Sayers & Binkley, 2008). There are two possible variations of the VJ test, each with its own pros and cons. The most accurate way to measure VJ is via the use of a portable force plate. However, if there is no access to a force plate available, a Vertec measuring device can be used. Furthermore, a VJ can be performed with the player either doing a squat jump with the hands on the hips or, a counter movement jump (Sayers, Sayers & Binkley, 2008).

Upper body power can also be tested for soccer performance due to the common technique of throw-ins needing applicable power to be successful. A seated medicine ball throw has been recommended which involves the player explosively pushing the ball from the chest in a seated position with the longest throw recorded. However, this method requires the player to be seated on a bench and strapped to an adjustable back support (Sayers, Sayers & Binkley, 2008). Therefore, it is potentially problematic for field-testing circumstances and an alternative may be needed in this case. A more appropriate test is an overhead medicine ball throw, which replicates a soccer throw in whilst testing for upper body power. Nevertheless, to date there have been no soccer specific tests for upper body power replicating a throw in. However, there has been an overhead medicine ball throw that is National Football League (NFL) specific (Mayhew, et al, 2005).

2.3.3 Flexibility

Flexibility is considered to be an important aspect of fitness for athletes and players in the majority of sports mainly due to its capacity to potentially decrease the risk of injuries such as sprains, strains and overuse injuries (Witvrouw, Danneels, Asselman, D'Have & Cambier, 2003). It has been suggested that the causes of many general injuries are considered to be complex and multifaceted but the consensus is that inadequate flexibility, strength, fatigue and warm up are the most common sources (Dadebo, White & George, 2003; Witvrouw, Danneels, Asselman, D'Have & Cambier, 2003). Essentially, it is suggested that there is a correlation between the level of flexibility demonstrated and the development of injuries. A study by Witvrouw, Danneels, Asselman, D'Have and Cambier (2003) concluded that there were significant associations between muscle tightness at pre-season and the subsequent development of injuries to the hamstring and quadriceps muscles. Although stretching protocols have previously been stated to increase flexibility, it is still questioned as to what the optimal level of flexibility is in order to reduce injuries. Additionally, it is also necessary to ensure flexibility is trained for sports specificity so it is essential that coaches and players are aware of the demands of their respective sport so that the respective muscle groups and movements can be targeted (Dadebo, White & George, 2003). The most common test for hamstring flexibility is the sit and reach (S&R) test as it is easy to implement and it is often used in team sports as it can be executed in a field-testing session (Wells & Dillon, 1952).

2.3.4 Speed

Although the aerobic system plays an integral role in maintaining the intensity level during short bursts of activity during a game of soccer, the anaerobic system also plays a significant role during this time (Meckel, Machnai & Eliakim, 2009). This role is important as the multiple sprints that are performed by a player during a game impose a different physiological stress than the prolonged single activity that is presented by a continuous run and therefore, may reflect differing physiological capabilities (Meckel, Machnai & Eliakim, 2009). It is therefore important that anaerobic testing protocols should reflect the player's specific sports activity movements (Meckel, Machnai & Eliakim, 2009).

Traditionally, tests used for the evaluation of aerobic and anaerobic capacities generally only use one continuous effort that lasts up to several minutes. One of the most reliable and popular anaerobic tests utilized is the Wingate Anaerobic Test (WAnT), which involves measuring a continuous, all out exercise and is commonly used to assess the anaerobic capabilities of multi-sprint athletes. However, the application of this test within intermittent sports such as soccer has been deemed questionable and therefore, it is suggested that more sports specific tests that are appropriate for prolonged, intermittent type activities be used. For example, several testing procedures (termed Repeated Sprint Tests (RSTs)) have been developed to evaluate anaerobic capacity by short, repeated, maximal efforts. Various protocols have been established such as 8-10 repetitions of 5 seconds sprints starting at 30-second intervals (Meckel, Machnai & Eliakim, 2009). Although the WAnT has been proved to be a valid method of testing, single-sprint tests are suggested to be a more specific way of testing speed within the game of soccer. These single-sprint tests can either begin with the player standing to start, or with a flying start involving the player beginning either walking or jogging before breaking into the sprint (Sayers, Sayers & Binkley, 2008). Generally, the common consensus is that the longest sprint a player may perform during a game is 40 metres (Davis, Brewer & Atkin, 1992; Dupont, Akakpo & Berthoin, 2004; Hoff, Wisloff, Engen & Helgurad, 2002). However, it has also been stated that 49% of sprints are shorter than 10 meters (Sayers, Sayers & Binkley, 2008) so ensuring there is a timing gate set at this distance point also allows for analysis of acceleration time over short bursts of speed. Although a stopwatch can be utilized, it is recommended that electronic timing gates be used to measure time as they have a lower rate of human error, which has the opportunity to impact the reliability and validity of the test (Sayers, Sayers & Binkley, 2008). Additionally, as soccer is a game that requires players to be able to run whilst performing skills with the ball at a sufficient level, it is important that fitness testing also incorporate sprints both with and without the ball to establish whether speed weaknesses may be due to inclusion of the ball. This type of testing can also determine whether additional training such as coordination training could help enhance ball skills at speed (Venturelli, Bishop & Pettene, 2008).

2.3.5 Agility

Agility is deemed to be an important component of soccer as it is defined as “the ability to change the direction of the body rapidly using a combination of strength, speed, balance and coordination” and thus, replicates the repeated movements performed during the game (Sayers, Sayers & Binkley, 2008, pp. 72). It is important for coaches to understand the difference between agility and change of direction, which can be defined as a movement that is “preplanned” and “produced in response to a stimulus such as an opponent’s actions” (Young & Farrow, 2006, pp. 24). Often these two physical aspects are incorrectly used interchangeably so it is important to distinguish between the two.

There are a number of agility tests including the Illinois agility test however, more soccer specific agility tests include the 505 agility test (Sayers, Sayers & Binkley, 2008) and the Balsom agility test (Balsom, 1994). Generally, the main aim of these tests is for the player to complete the set task as quickly as possible and thus, it is suggested that two to three trials be completed to allow for the chance to perform the test as best achievable. Additionally, Little and Williams (2005) recommend that agility tests be used in conjunction with single-sprint tests to obtain an indication of an athlete's speed capacity. Therefore, it may be useful to evaluate both tests together to evaluate an athlete's ability to change direction and speed rapidly, without a loss in balance (Sayers, Sayers & Binkley, 2008).

2.4 Previous Literature on Seasonal Fitness

In regards to changes in seasonal fitness, there have been previous studies that have focused on investigating it in a number of sports. Numerous studies have reported a positive change in seasonal fitness in various fitness variables using fitness testing similar to the aforementioned. For example, Gonzalez-Rave, Arika and Clemente-Suarez (2011) found encouraging results with elite female volleyball players reporting an increase in anthropometric variables such as muscle mass and fat free mass as well as power and strength. In addition, there was also a decrease in body fat percentage. The positive trend in seasonal fitness changes has also been proven to extend to individual sports including alpine skiing and cycling with improvements in VO_{2max}, heart rate and jump height and peak power were found respectively (Paton & Hopkins, 2005).

However, a positive change in fitness is not always evident throughout a season. There have been a number of studies that have concluded that there are deteriorations or plateaus in fitness throughout the season. For example, Miller et al. (2007) and Silvestre et al. (2006) have reported a reduction or no significant changes in aerobic fitness throughout a season in soccer players at the collegiate level.

In order to gain more of an understanding of what is currently known about seasonal fitness in soccer in particular, a review was completed of the existing studies that have analyzed athlete's fitness throughout a season at both the elite (Table 2.1) and sub-elite (Table 2.2) level.

Table 2.1 Comparison of significant changes in seasonal fitness of elite soccer teams in previous studies

Study & Division	**Age of Players (yrs)**	**Number of Training Sessions/week**	Fitness Variable						
			BMI/ Body Mass	**Body Fat %**	**Flexibility**	**Lower Body Power (CMJ)**	**Agility without Ball**	**Speed (10m-50m)**	**VO_2 max**
English First League First Division (Thomas & Reilly, 1979)	18-29	5 trainings sessions/week Games: 1-2	No change	(-)	(-)	CMJ: No change	(-)	(-)	Treadmill protocol: No change
Spanish First Division (La Liga) (Casajus, 2001)	25.8±3.19	Training: 6-7 Games: 1-2	Body mass: No change Skin Fat: ↑	↑	(-)	CMJ: No change	(-)	(-)	Incremental treadmill test: No change
First National League Yugoslavia (Ostojic, 2003)	23.5±3.1	Not stated	↑	↑	(-)	(-)	(-)	50m: ↑	(-)
Professional European (Dupont,		MAS Training 2 x /week and normal	No	No	(-)	(-)	(-)	↑	↑

Akakpo & Berthoin, 2004)		training sessions	change	change					
Singoporean S-League team (Arziz, Tan & Teh, 2005)		4-5 training sessions/week	No change	No change	(-)	↑	(-)	↑	↑
English Championship Club (Clark, Edwards, Morton & Butterly, 2008)	25±3.5	Not stated	No change	No change	(-)	CMJ: ↑	(-)	(-)	Treadmill protocol: No change
Glasglo Celtic Football Club (Somerville, 2009)	Under 17-19	S&C: 4+ Technical and Skills: 6+ Games: 1	No change	(-)	(-)	CMJ: No change Squat Jump: ↑	(-)	5m: No change 10m: No change	No change
Greek National Level (Kalapotharakos, Ziogas & Tomakidis, 2011)	25±5	S&C/Skills: 6 Game: 1	No change	↑	(-)	(-)	(-)	(-)	Treadmill protocol: ↑
Portuguese Elite Championship Team (Silva et al., 2011)		Not stated	(-)	(-)	(-)	No change	↑	No change	YYIR2: ↑

- ↑ There was a significant improvement in fitness variable during the season
- ↓ There was a significant decrement in fitness variable during the season
- (-) Study did not produce results for fitness variable

Table 2.2 Comparison of significant changes in seasonal fitness of sub-elite soccer teams in previous studies

Study	Age of Players (yrs)	Number of Training Sessions/week	Fitness Variable						
			BMI/ Body Mass	**Body Fat %**	**Flexibility**	**Lower Body Power**	**Agility without Ball**	**Speed without Ball (10m-50m)**	**VO_2 max**
NCAA Division 1 Team (Silvestre et al., 2006)	19.9±1.3	S&C: 3-4 Technical and Skills: 4-5 Games: 1-2	Body Mass: ↓	↑	(-)	VJ: No change	(-)	9m: No change 36m:	YYIR2: No change
NCAA Division III Team, USA (Magal, Smith, Dyer & Hoffman, 2009)	20.0±0.9	Not stated	No change	No change	(-)	Wingate Test: No change	Pro Agility Test: No change	10m:↑ 30m: ↑ 40m: No change	↑
English Nation Wide Conference (Caldwell & Peters, 2009)	24±4.4	S&C/Skills: 2 Games: 1-2	(-)	↑	S&R: ↑	VJ: ↓	Illinois Agility Test: No change	15m: ↑	No change

2.4.1 Comparison of Elite and Sub-Elite Studies

2.4.1.1 Studies Overview

Literature shows that there are minimal trends of improvement or deterioration in any fitness variable at both the elite and sub-elite level. All studies except one tested for aerobic capacity (VO_{2max}) alterations during the season and it is evident that there were varying results concluded with both significant improvements (Arziz, Tan & Teh, 2005; Dupont, Akakpo & Berthoin, 2004; Kalapotharakos, Ziogas & Tomakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Silva et al., 2011) and no changes (Caldwell & Peters, 2009; Casajus, 2001; Clark, Edwards, Morton & Butterly, 2008; Silvestre et al., 2006; Somerville, 2009; Thomas & Reilly, 1979) being reported at both levels. However, in no study did aerobic capacity diminish significantly.

2.4.1.2 Anthropometric

Literature has stated that anthropometric characteristics have been proven to be an indicator of success in high levels of soccer (Clark, Edwards, Morton & Butterly, 2008; Kalapotharakos, Ziogas & Tokmakidis, 2011). Therefore, measures such as body mass, body mass index (BMI) and body fat percentage (BF) are considered vital indicators of performance in athletes and improvements in these throughout the season are often desired. Throughout the season, there were no significant changes reported in BMI in any previous studies except that of Silvestre et al. (2006). However, there were conflicting results regarding changes in BF throughout the season with 50% of the elite teams and two out of three sub-elite teams reporting significant improvements whilst the remaining elite teams and single sub-elite team concluded no change. However, it is important to consider the limitations of some of the methods the studies may have employed when measuring anthropometric measures. There are a variety of different resources to use including electronic scales, skin callipers and body composition scans and there are both pros and cons to using all of them. It has been suggested that there are some technical errors that can occur when using electronic scales causing inaccurate results so their utilisation may not always be suitable. (Clark, Edwards, Morton & Butterly, 2008). However, as long as the investigator is aware of their limitations they may still be utilised such as situations with time and equipment restraints. Consequently, the method of skin callipers such as that used in the studies focusing on the elite Greek and Spanish teams may prove more adequate (Casajus, 2001; Kalapotharakos, Ziogas & Tokmakidis, 2011). It should be noted however, that both of these teams were at the elite level and thus, most likely had better access to personnel. Additionally, teams at the lower levels of professionalism often have no choice but to use more time appropriate measures for body fat such as scales due to the time constraints placed on them.

2.4.1.3 Flexibility

Changes in physiological aspects of fitness have previously been suggested to rely on the strength and specificity of the training program as well as its implementation. Caldwell and Peters (2009) reported a significant improvement in flexibility during a season in a sub-elite English soccer team. The positive change was deemed to have occurred due to the "moderate" to "high" levels of flexibility training that was sporadically included throughout the season. Thus, it could be suggested that a team that completed no specific flexibility training would not have such promising improvements.

2.4.1.4 Power and Strength

As lower body power is considered to be a necessary component of fitness in soccer due its assistance in many specific movements, it is a common aspect measured for change in many soccer teams with VJ performance being the most popular method of determining power (Arziz, Tan & Teh, 2005; Caldwell & Peters, 2009; Casajus, 2001; Clark, Edwards, Morton & Butterly, 2008; Magal, Smith, Dyer & Hoffman, 2009; Silva et al, 2011; Silvestre et al., 2006; Sommerville, 2009; Thomas & Reilly, 1979). Clark, Edwards, Morton and Butterly (2008) reported a significant increase in lower body power at post season and suggested that this improvement was due to a training effect in which a greater coordination of the respective muscle groups resulted in more effective and powerful jumps. Caldwell and Peters (2009) agree stating that improvements in lower body power can be enhanced throughout the implementation of basic, functional muscle strength training such as plyometric and weight training. These results support the suggestion that the implementation of appropriate conditioning training throughout the season has the most impact on whether players will experience improvements or not. In contrast, a number of previous studies that did not specify having a large focus on specific strength and power training throughout the season reported no positive changes in VJ performance (Caldwell & Peters, 2009; Casajus, 2001; Magal, Smith, Dyer & Hoffman, 2009; Thomas & Reilly, 1979; Silva et al, 2011). Therefore, the inclusion of specific strength and power conditioning training is desirable for improvements in soccer performance.

2.4.1.5 Agility

Agility is a component of fitness that has been deemed essential within the game of soccer however there has been minimal research on the seasonal variations in agility performance (Caldwell & Peters, 2009; Magal, Smith, Dyer & Hoffman, 2009; Silva, et al., 2011). Only three of the studies (two sub-elite and one-elite) included in this review included agility testing and the only study that reported an improvement in performance was the elite Portuguese team (Silva et al, 2011). This improvement was deemed to have been due to improved muscle coordination, which was enhanced with specific functional strength training once a week throughout the season. Thus, it is suggested that agility is yet another element of fitness in soccer that is highly dependent on individualised conditioning training (Silva et al, 2011).

2.4.1.6 Speed

Similarly to agility, speed is commonly tested in soccer players as it is of great importance in a game due to the high number of sprints within each game (Wong, Hejelde, Cheng & Ngo, 2015). Five studies focusing on elite teams and all three sub-elite studies included speed testing within their methods and over half of them reported improvements during a season. Additionally, the length of the sprints involved in each study differed yet this did not appear to influence the general results of seasonal fitness. For example, the five studies that reported significant improvements in speed used differing sprint distances ranging from nine metres to 40 metres (Magal, Smith, Dyer & Hoffman, 2009; Caldwell & Peters, 2009; Dupont, Akakpo & Berthoin, 2004; Arziz, Tan & The, 2005; Ostojic, 2003). However, it is important to note that not all teams who performed sprints at these distances experienced the same positive results as the remaining three studies who did not report improvements utilized similar tests (Silvestre et al, 2006; Somerville, 2009; Silva et al, 2011). Additionally, previous research has suggested that a decrease in BF often accompanies an increase in speed throughout a season (Ostojic, 2003; Silvestre et al, 2006). Nevertheless, this relationship was not found to exist within all teams compared within this review and thus, more research may be needed to confirm this conclusion. Again, teams who implemented specific sprint conditioning training within the season concluded improvements in speed. This also included the two sub-elite teams who despite only two training sessions a week, still reported positive findings which may have been due to the professional assistance provided during conditioning training (Caldwell & Peters, 2009).

2.4.1.7 Aerobic Capacity

Aerobic capacity, deemed to be one of the most important physiological aspects of fitness within soccer, needs to be focused on when determining seasonal fitness changes for a number of reasons. Potentially most importantly, it needs to be a focus as it can assist in the implementation of specifically designed training sessions throughout a season (Kalapothrakos, Ziogas & Tomakidis, 2011). Although aerobic capacity may be an essential fitness variable that coaches and players want to improve during the season, this is not always the case. Studies by Casajus (2001), Silvestre et al. (2006), Cardwell and Peters (2009), Thomas and Reilly (1979) and Somerville (2009) all found no significant change in aerobic performances during their respective seasons. It should be noted that a number of different protocols including treadmill and YYIR2 methods were also utilised to determine changes in aerobic capacity within this group of studies. Thus, it may be suggested that it was indeed the physiological variable itself that did not change as opposed to investigators simply choosing an inadequate protocol. Similarly, Clark, Edwards, Morton and Butterly (2007) found that over a period of three seasons, an elite soccer team also showed no significant improvements in aerobic performance during any individual season. A common explanation as to why teams may not see improvements during a season is that the players have already reached near VO_{2max} at pre-season testing and may have therefore found it hard to improve much further throughout the season (Caldwell & Peters, 2009; Ekblom, 1989). However, it is difficult to determine if this was the sole reason for no improvements in aerobic capacity within these aforementioned teams as not all studies disclosed the details of the training sessions the respective players undertook.

In contrast, there has also been previous literature that concluded positive improvements in aerobic capacity in soccer players during a season at both the sub-elite and elite levels (Arziz, Tan & The, 2005; Dupont, Akakpo & Berthoin, 2004; Kalapothrakos, Ziogas & Tomakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Silva, et al., 2011;). It has been suggested that those teams who reported a large improvement in aerobic performance at post season testing, may have done so as a result of players starting the season at a less than optimal aerobic capacity levels. Therefore, the player's aerobic performances could then be improved upon during the season with some ease (Casajus, 2001; Magal, Smith, Dyer & Hoffman, 2009; Silva, et al., 2011).

2.4.1.8 Method of Training

Similarly to the previous performance variables mentioned within this review, the method of training that was implemented during sessions has been deemed to play a part in the outcome of fitness testing. It is commonly thought that aerobic training needs to be the main component of training sessions in order to improve aerobic capacity during the season. However, Dupont, Akakpo and Berthoin (2004) offered an alternative theory when an elite European soccer team's aerobic performance was improved post season following maximal anaerobic speed training implementation. Nonetheless, teams that reported a high use of SSG within training sessions did not report the same improvements. These findings may have highlighted the lack of specific conditioning implemented and demonstrated that SSG alone may not be of a high enough stimulus to induce aerobic capacity improvement. Additionally, as previously mentioned, the YYIR1 test is a common tool often utilised to test aerobic capacity in soccer players. The YYIR2 was used in testing both an elite (Silva et al., 2011) and sub-elite (Silvestre et al., 2006) team for detection of seasonal changes in fitness in aerobic performance. However, only the elite team reported a significant improvement and thus it could be suggested that the YYIR2 test may not be appropriate for players at the more amateur level.

2.5 Reasons for change or lack thereof in fitness in elite and sub-elite soccer teams

As elite soccer players have been deemed to have higher levels of physical performance abilities, it would be expected that there would be a substantial difference between the seasonal changes in fitness of elite and sub-elite soccer teams with the former predicted to perform better. However, following a review of recent literature, there are no considerable differences between the two levels of professionalism. These findings are similar to those concluded by Arnason et al. (2004) who stated that there were no significant differences in the fitness results of elite and first division soccer teams in Iceland.

A number of reasons exist as to why athletes may improve, deteriorate or maintain fitness throughout a season. Athletes who show an improvement in fitness throughout the season may have started the season with less than optimal levels of fitness and training and thus, competition demands may provide an adequate stimulus to improve fitness. Those athletes who plateau in fitness may have produced sub-standard results during pre-season testing and may then over train during the pre-season in an effort to improve fitness to prepare for the forthcoming competitive season. This can result in these athletes succumbing to mental and physical fatigue during later stages of the season (Caldwell & Peters, 2009; Kraemer et al., 2004). Additionally, an athlete may experience a diminished performance throughout a season due to detraining and demotivation being caused by a prolonged season (Bangsbo, Iaia & Krustrup, 2008; Silva, et al., 2011).

Match experience and the number of games players are exposed to throughout a season can also have an impact on seasonal variation in fitness. Mohr, Krustrup and Bangsbo (2003) reported decreases in the ability to perform high-intensity running during games in elite soccer players involved in National and European competitions (2 matches per week) toward the middle of the season, during which there is limited time for fitness training and more time for recovery is needed. Interestingly, Kraemer et al. (2004) also observed that starter players who usually accumulate more match playing time experience greater performance decrements in some fitness parameters.

Seasonal variations in fitness have been extensively investigated in male soccer players of differing ages, nationalities and levels of competition (Caldwell & Peters, 2009; Gil et al., 2008; Gravina, Gil, Ruiz, Zubero, Kalapothrakos, Ziogas & Tokmakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Ostojic, 2003). Although seasonal fitness has been extensively investigated in soccer players at the professional level, there is a lack of research focusing on sub-elite players who experience a limited opportunity for conditioning (Caldwell & Peters, 2009). Additionally, majority of the research has only focused on a few fitness components and therefore, a holistic evaluation of the players is not presented. In addition, previous literature has only presented results on limited time intervals throughout a season (for example, pre and post season or pre and mid-season) as opposed to regular intervals such as during the off season, pre-season, mid-season and post season time points (Caldwell & Peters, 2009; Gravina, et al., 2008; Kalapothrakos, Ziogas & Tokmakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Ostojic, 2003). These various fitness testing's are essential to identify the points in time during the season where these changes may be occurring.

Modalities and methods of training such as periodization and training focuses can also influence changes in performance (Turner & Stewart, 2014). In the current review, the sub-elite teams demonstrated a high use of SSG with minimal unassisted S&C training. In comparison, majority of the elite teams generally have completely supervised S&C training sessions multiple times per week in addition to normal and SSG training. This difference in personnel for assistance between levels tends to be due to the disparity in financial accessibility with the elite teams generally having additional funding (Grove, Lavallee & Gordon, 1997). Thus, it could be suggested that teams at the elite level often have more opportunities to enhance fitness through better training assistance and higher levels of fitness training and competition.

Furthermore, it is evident that sub-elite level teams have less training sessions and games per week than their more elite counterparts with elite teams reporting approximately four to seven training sessions per week (Arziz, Tan & Teh, 2005; Kalapotharakos, Ziogas & Tomakidis, 2011; Silva et al., 2011; Somerville, 2009).

In a bid to improve fitness, tactics and skills within a limited period of time, amateur teams, such as those in Australia, rely highly on SSG as seen used by elite and sub-elite teams. However, the current review suggests that this technique of training may not be appropriate to increase performance variables in teams below the elite level due to a lack of skill set and evident lack of access to professional S&C assistance (Silevestre, et al., 2006). Moreover, elite and sub-elite teams who incorporated S&C training in addition to normal training sessions during the season presented improvements in at least one or two fitness variables at post season testing.

Additionally, no literature to the author's knowledge has investigated the effects of attendance rates on seasonal variations in fitness in any sports including soccer. Attendance rates may be a significant factor in predicting performance changes as a lack of attendance may cause decrements in performance throughout a season and thus, must be analyzed in more detail to establish a more concise conclusion.

In conclusion, sub-elite teams using SSG in an attempt to improve fitness variables have not exhibited as successful improvements when compared to their elite counterparts. Time and financial constraints in conjunction with a lack of accessibility to appropriate S&C assistance all play a role in preventing increases in fitness. It is suggested that for players to have the best opportunity to increase fitness during a season, coaches of sub-elite teams consider the level of skill and time availability of their players when designing and implementing training sessions.

2.6 Training

2.6.1 The importance of training in maintaining fitness throughout a season

For an athlete to perform at an optimal level within their chosen sport, it is required that they implement some form of physical training such as aerobic or strength training (Caldwell & Peters, 2009). By implementing training techniques aimed at increasing physical fitness, it allows for the athlete to prepare their body to not only acquire but also maintain a good level of physiological fitness that is required to perform a specific exercise or task (Caldwell & Peters, 2009). As previously discussed, there are a number of different ways in which soccer teams train including skills and tactical training, SSG and specific S&C training. However, there are a number of factors that can impact the coach's decision of what method of training should and will be implemented such as the level of the competition, the skill ability of the players and the time and financial constraints the team faces. The types of training that are implemented during a season are often determined by what the coach desires as most important for team success.

In order to optimize an athlete's performance, it is suggested that physical training should be prescribed to suit the characteristics of each individual (Alexiou & Coutts, 2008). However, in team sports, individual players are generally involved in training sessions that are aimed at developing the fitness and technical-tactical skills of the entire team. However, this whole-group training approach can then lead to the potential of differentiated training responses between players as the players are not likely to receive specific training based on their characteristics. Thus, differences can then result in the training session individualization being challenged and the optimal development of performance that is assumed to be encouraged, is in fact prevented as individuals are not responding appropriately (Alexiou & Coutts, 2008; Manzi, Bovenzi, Impellizzeri, Carminati & Castagna, 2013). This detrimental training effect has been demonstrated by Hoff et al. (2002) when it was found that those soccer players with superior fitness did not receive a sufficient stimulus to further challenge their fitness during training when in a team training situation using SSG based methods. Similarly, Impellizzeri, Rampinini and Marcora (2005) found that players with lower fitness levels may become overstressed and have a reduction in performance as well as suffer from being at an increased risk of injury and fatigue in the same situation of team training sessions. Together these findings suggest that individuals may not receive an adequate level of training stimulus when placed in a team-based training approach.

Therefore, it is suggested that training be individualised where possible to ensure that players have the best chance at improving fitness during the season based on their own physical performance.

2.6.2 Why are SSG used to train fitness?

In the modern day game of soccer, coaches are continuously on the lookout for new modified games and drills that produce the opportunity to concurrently train technical, tactical and physical capacities of players. Although periodized training has been a prevalent way of acquiring and maintaining the fitness in soccer players for quite some time, an alternative option in the form of SSG (also known as the Dutch model of training) has been developed in previous years to incorporate the technical and tactical elements of the game at the same time (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). Due to these factors, SSG are often desirable for coaches as it is believed they concurrently train and develop the key elements and qualities that are required regardless of the level or age of the player (Dellal et al, 2008; Hill-Haas, Coutts, Dawson & Rowsell, 2010; Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). The idea behind this SSG method of training is that instead of the 10 players (plus the goal keeper) that are involved in a full sized game, there are generally four to five (or less) players in a team. Additionally, the games are played on a reduced sized pitch to accommodate for the smaller number of players involved (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). This method of training has proved popular and is now commonly used in not only pre-season training, but also during the competitive season (Aguiar, Botelho, Goncalves & Sampaio, 2013; Dellal, Hill-Haas, Lago-Penas & Charmari, 2011; Jeong, Reilly, Morton, Bae and Drust, 2011; Kelly & Drust, 2009; Impellizzeri et al., 2006; Rampinini et al., 2007). There has been much debate as to whether generic aerobic training or SSG's is the more appropriate method of training for soccer. Thus, the main theory behind using training techniques such as SSG's is that match readiness and fitness can be trained via the use of playing games (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011; MacLaren et al., 1988; Reilly & Bangsbo, 1998). Due to this, coaches of team sports such as soccer choose to utilize SSG and interval training techniques to assist with gaining and maintaining fitness whilst still focusing on the tactical and technical elements of the game (Caldwell &Peters, 2009; Dellal, Hill-Haas, Lago-Penas & Charmari, 2011;).

Apart from allowing for concurrent training of multiple components required within soccer, there are a number of other proposed positive elements that come with the technique of SSG training. SSG are believed to enhance a number of physical variables including endurance, maximal oxygen uptake and aerobic capacity (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011; Hill-Haas, Coutts, Rowsell & Dawson, 2009; Mallo & Navarro, 2008). It is suggested that the method of SSG training allows for the attainment of a similar level of maximal heart rate to that observed during a soccer game and therefore, replicates similar aerobic conditions (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). Furthermore, if performed correctly, SSG also offer the opportunity for players to perform the same short intensity sprint efforts that are seen within a game (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). SSG have also been proposed to be an ecological and valid technique to improve specific fitness in soccer (Rampinini, et al., 2007). When simulating real match situations, SSG drills have the ability to develop agility and change of direction speed in youth soccer players (Chaouachi, Chtara, Hammami, Chtara, Turki and Castagna, 2015; Davies, Young, Farrow and Bahnert, 2012). In particular, by manipulating the number of players, the pitch dimensions and the rules of play it is possible to recreate match situations, place the players under pressure and create opportunities for players to receive more involvement with the ball and thus, more opportunity to gain match-specific fitness by extending neuromuscular demands (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). Players also report feeling more motivated and enjoying training more when SSG's are implemented within training and thus, this method encourages players to perform at a higher intensity during sessions. Furthermore, as SSG have been shown to engage the same muscle groups, technical and tactical skills as those utilized and displayed during an actual game, there is a significant sport-specific training crossover that encourages a transfer from training to the competitive environment. Coaches of junior players in particular are fond of this method of training as it allows for both aerobic fitness and tactical-technical elements to be trained concurrently (Impellizzeri et al., 2006). For these reasons, it is becoming more common for clubs at all levels of the game to include the SSG method of training as part or all of their training sessions (Impellizzeri et al., 2006).

However, although SSG's have been shown to help enhance the fitness of soccer players, there are a number of considerations that must be taken into account to induce these positive results and even then, they may still not be seen. For example, the effect of this training method has been shown to only enhance generic aerobic fitness and specific endurance in young soccer players at the semi-professional level (Impellizzeri, Marcora, Castagna, Reilly, Saddi, Iaia & Rampinini, 2006). When comparing the time motion analysis of SSG training, there was a significant difference in amateur and professional players in regards to the total sprint distance covered and high intensity running with the amateur players performing less distance and less running at a high intensity. Indeed, the distance covered within a match has often been deemed as the determining factor between differing levels of competition with more professional players performing better when compared with amateur levels (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). As the ability to complete multiple sprints with minimum rest is an important component of elite soccer, those teams aiming to be at a higher level must be able to replicate the same intensity of sprints and recovery within the SSG method of training for the technique to be successful (Rampinini et al., 2009). Impellizzeri et al. (2006) found a similar result stating that there were no significant differences between the use of SSG and generic aerobic training in soccer specific fitness tests in junior players. This suggests that both SSG's and running are equally effective techniques of interval aerobic training in soccer players (Impellizzeri et al., 2006). Thus, SSG may not always be the most appropriate method of training for aerobic soccer fitness for all levels of players.

Furthermore, the format of SSG's in terms of how many players are on each side has been shown to have an impact on the effectiveness of the game on inducing performance improvements. Overall, the less players there are on a side in a SSG, the more the game reflects what occurs in a competitive game (Impellizzeri et al, 2006). It then becomes important to determine the correct number of players involved in the game to induce the positive training effect desired.

The rules determined by the coach of the SSG may also have an impact on the result. Commonly, the coach will want to increase the playing intensity and will often ask for few touches on the ball when in possession (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). However, this rule will have differing impacts on the players, depending which level of the game they are at. The technical pattern is considered to be an important aspect in the differentiation between amateur and professional playing level. Dellal, Hill-Haas, Lago-Penas and Charmari, (2011) and Dellal, Wong, Moalla and Charmari (2010) state that players at the professional level require better technical ability than their amateur counterparts. This suggestion is supported by Dellal, Hill-Haas, Lago-Penas and Charmari's (2011) study that concluded that amateurs appeared to be less technically proficient than professional players as they had produced a greater number of loss of possession's and skill errors including missed passes. As the ability to produce high quality passes has a positive relationship with the success of goals in professional soccer, it is essential that players perform at the optimal level during training in order to practice this skill (Oberstone, 2009; Rampinini et al, 2009). The technical ability of the players involved is important to consider when implementing SSG into training as previous literature has concluded that amateur players often don't have the skill capacity to maintain optimal performance once rules such as one or two touch limits are applied (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011). Thus, it may be suggested that if the skill of the player is not adequate, SSG training may not be appropriate as a high intensity may not be held throughout the duration of the session and perhaps another method of training may be required in addition to SSG to train for fitness (Dellal, Hill-Haas, Lago-Penas & Charmari, 2011; Wong et al, 2010).

Keeping in mind the above considerations, it has been suggested that coaches acknowledge a number of considerations before implementing SSG into training sessions as the sole method of training for soccer players. Currently, it is still questioned as to whether SSG is indeed the appropriate training technique for all levels of players as both positive and negative conclusions have been drawn regarding the method. More research is needed to determine whether SSG are appropriate for training technical and tactical skills as well as fitness in amateur, junior and female soccer players.

2.6.3 Who is using SSG to train?

Previous literature has established that the SSG method of training is common at all levels of professionalism within soccer. In particular, teams within European countries utilize the SSG technique within training at the elite, sub-elite and amateur levels (Castellano & Casamichana, 2010; Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Roswell, 2010; Mallo & Navarro, 2008). Teams within Australia are now attempting to adopt the same strategy. There are a number of reasons as to why this method may not be appropriate in certain countries and teams and these will be discussed in detail below.

2.6.4 Why SSG may not be the best method of training for all players

While SSG have been shown to have a positive impact on the fitness of elite male soccer players, they may not have the same influence on all types of players including females and those at the sub-elite or amateur levels. For example, a study performed on elite female players focusing on the impact of 3- and 5-a-side SSG formats concluded that although SSG of this size may simulate the overall movement pattern of a competitive match, they didn't replicate the same level of fitness (such as high-intensity repeated sprints) or heart rate (HR) responses. Thus, the SSG format may not always reproduce the demands of competition fitness variables (Aguiar, Botelho, Goncalves & Sampaio, 2013). Dellal, Hill-Haas, Lago-Penas and Chamari (2011) also concluded that across a variety of SSG amateurs recorded a higher RPE, completed a significantly lower percentage of successful passes, higher lactate values, covered less total distance sprinting at high intensity and lost a greater number of ball possessions than their professional counterparts. It is evident that a player's level of skill may have an impact on the physical, technical and physiological responses to SSG training and thus, amateur levels who present a lower level of skill, may not always have the same positive results to this technique of training as professionals (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011).

Although amateur and sub-elite players have been reported to train in a similar way to their elite counterparts (with a high focus on SSG), it is heavily questioned as to whether it is the most appropriate method for teams at the lower levels of professionalism. It is of particular interest as to whether SSG is an efficient technique of training that also allows for fitness to be trained concurrently with skills to encourage a more well rounded athlete. Additionally, there is a lack of research on the impact of SSG training for fitness in Australian soccer players, particularly at the sub-elite and amateur levels. As there are only 10 teams in the men's top league within Australia and nine teams in the women's top league, majority of the players within the country are deemed as sub-elite or amateur level (Football Federation Australia, 2016). Therefore, there is a need for more research on the effect of SSG training on fitness at these lower levels professionalism.

2.7 Injuries

2.7.1 The importance of injuries in seasonal fitness

In addition to the training methods employed, one major factor that influences player's fitness during the season is injuries and it is essential that this be taken into consideration when collecting seasonal fitness data. Of the aforementioned factors, injuries have the opportunity to have biggest impact due to a number of reasons and it is important to expand on this to illustrate the effect they can have on players and their fitness.

In this thesis, an injury is defined as any time "a player was hurt in any way that prevented them from performing a training session or game at 100% ability, or any physical complaint irrespective of time lost from physical activity or the medical attention" (Fuller, et al., 2006). This definition is used multiple times within this thesis and is the basis of the injury data sheets utilised in data collection (see Appendix 12.2). Injuries can come from both intrinsic factors such as physical characteristics, ability, age, gender and fitness and extrinsic factors including exposures, equipment and environment (Lauersen, Bertelsen & Andersen, 2014). Additionally, injuries can also occur from a latitude of sources such as player position. Taking The data sheets within this thesis have been designed taking into account these potential injury considerations (refer to Appendix 12.2 for example).

In order to obtain a good competition ranking, soccer players have to be well trained, talented and healthy (Stubbe, et al., 2014). However, soccer is similar to the majority of sports as it presents the opportunity for injury risk at all levels of competition including both amateur and elite groups (Junge, 2004; Yard, et al., 2008). In fact, previous literature has even stated that soccer can present the highest number of injuries when compared to other sports. In a 10-year study conducted by Majewski et al. (2006) it was reported that soccer contributed to 37% of the injuries reported from a pool of 19, 530 injuries. In comparison, skiing was the second highest accounting for 26% of injuries demonstrating just how many injuries soccer contributed to the overall total (Majewski, et al., 2006). Additionally, as injuries can often require rehabilitation or surgery and interrupt a player's activity for weeks or even months, they are a major concern during a player's career and as soccer presents such a high number of injuries, it is important to discuss all the contributing factors and how prevention can be aided (Majewski, et al., 2006; Stubbe, et al., 2014). Moreover, as shown with fitness and training, there are generally differences between different groups of players such as seniors and juniors, differing levels of professionalism and gender. Therefore, it is necessary to compare these groups again in regards to injuries to gain a full understanding into how seasonal fitness may be affected.

2.7.2 Senior injury rates

Previous literature suggests that there are variations in the rates of injury between youth and adult players. A recent review of literature by Faude (2013) concluded that the incidence of injury within soccer games is inclined to increase with age across all age groups but particularly in those over 15 years of age. In those over 15, there is an average incidence of 15 to 20 injuries per 1000 hours of match play (Faude, 2013). In comparison, only 11.2 injuries per 1000 hours of match play have been reported in junior players under 16 years of age (Le Gall, et al., 2006).

Injuries can impact player’s attendance at trainings or at the very least, cause the player to participate at a lower level on intensity than if they were in a fit state. Ekstrand, Hagglund and Walden (2011) stated that each team within the study reported on average 8.0 injuries/1000 hours and two injuries per player per year. Half of each teams injuries were considered to be minor and cause absence of less than a week while as many as eight or nine were severe injuries causing absence for more than a week. Thus, it was estimated that players in these European competitions missed 37 days within a 300-day season on average due to injury. Consequently, these injuries not only cost professional soccer clubs a significant financial burden, but also damaged the chances of success within competition. Grooms et al. (2013) agreed reporting that approximately 20% of injuries in soccer are considered to be severe and often require more than 10 days for a complete recovery thus, preventing players from training and game participation.

Although soccer is not considered to be a contact sport, players are still prone to getting injured in both games and training sessions. Junge and Dvorak (2004) reported injury rates of approximately 10 to 35 injuries per 1000 match hours and 2 to 7 injuries per 1000 training hours in international male soccer players. Additional previous literature also reported a higher injury incidence in matches than in training with approximately 24.6-34.8 and 5.8-7.6 injuries per 1000 hours respectively (Arnason, Andersen, Holme, Engebretsen & Bahr, 2008; Schmikli, de Vries, Inklaar & Backx, 2011).

2.7.3 Junior injury rates

Soccer is considered to be the most popular sport in the world partly due to the perception by the public that it is relatively safe sport for adolescents (Adams & Schiff, 2006). However, junior players also face different injury risks when compared to adults with literature concluding that soccer is one of the most common sports resulting in injury among youth players (Taylor & Attia, 2000). Following football and wrestling, soccer was recorded as the third highest injury incidence in US high school students during the 2005-2006 period (Nelson, Collins & Yard, 2007). In contrast to the findings by Faude (2013), research also states that soccer players under the age of 15 have a higher risk of injuries and tend to report a greater injury prevalence than their older counterparts (Kirkendall, Marchak & Garrett, 2002; Leininger, Knox & Comstock, 2007; Wong & Hong, 2005). This higher risk is often associated with the possibility that younger players may have undertaken too much training at a high intensity or still lack the injury-avoidance skills required in soccer when compared to adult players (Le Gall, Carling & Reilly, 2008). Previous findings also suggest that often, youth players compete in a cohort where individual's range from approximately 15-19 years of age and generally, all ages will play together. Thus, individuals may regularly play against more mature and older players on a regular basis and consequently, they may be playing with others who are larger and stronger. These circumstances can often lead to the younger players becoming more prone to injury and reporting higher injury incidences (Le Gall, Carling & Reilly, 2008). Another suggestion as to why youth players may be more prone to injuries is due to the fact that often younger players are less experienced and have limitations in tactical and technical ability, muscle endurance, strength and coordination (Le Gall, Carling & Reilly, 2008).

With research concluding that age can play a factor in injuries suggests it is important for coaches to consider these physiological and anatomical differences when designing training programs for their athletes. In particular, it is imperative to cater to the characteristics of the individuals and team as best as possible for optimal performance.

2.7.4 Male and female injury rates

Whilst it is important to discuss the differences in injury rates between senior and junior soccer players, it is also important to consider the difference between male and female players. This is necessary as literature states that due to their anatomical make up, female players are more prone to being injured than their male counterparts (Eniseler, 2005). Previously, there have been many investigations into the differences in injury incidence between genders with some studies paying particular attention to youth athletes and the differences in puberty changes between genders (Knowles, et al., 2006; Yard, et al., 2008). Yard et al. (2008) concluded in a study on male and female high school students that girls sustained 51.6% of the overall soccer-related injuries over the course of two seasons. Additionally, 65% of those injuries in females occurred during competition rather than training sessions in comparison to 55% in males suggesting that females are more susceptible to injuries in more competitive situations (Yard, et al., 2008). Interestingly, there is also conflicting literature on the injury rates of youth male and females. Ostenberg and Roos, (2000) stated that females soccer players reported 14.3 injuries per 1000 match hours while

Junge, Dvorak, Graf-Baumann and Peterson (2004) reported male players had an injury rate of 16.2 injuries per 1000 match hours. In addition to reporting more injuries per 1000 match hours, males have also been reported to have more injuries per 1000 training hours with a rate of 14.29 compared to 11.78 in females (Junge, Dvorak, Graf-Baumann & Peterson, 2004; Ostenberg & Roos, 2000).

Overall, literature suggests that any differences that occur between the injury rates of male and female soccer players is often due to the anatomical differences between genders (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). For example, females are more likely to sustain certain injuries such as anterior cruciate ligament (ACL) tears due to their larger Q angle and joint laxity when compared to their male counterparts (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). Due to the differences between genders and their respective injury rates and the increased susceptibilities of females it is important that coaches consider whether their players are males or females in order to aid in injury prevention through training methods where possible.

2.7.5 Elite and amateur injury rates

Further variances that can occur between individual players and teams are those that occur at the differing levels of play. As higher intensities of play are often associated with an increased risk of injury, the elite level of competition is often deemed to have higher injury incidences than at the amateur level (Le Gall, et al., 2006). This higher incidence has been suggested to be due to the physical demands of match play being higher at the elite level as it is generally an advanced standard of competition (Bradley et al., 2009). Additionally, higher levels of competition also often have more than one game per week and as a relationship has been shown to exist between two or more games a week and a higher injury rate, it is suggested that that elite players are more at risk of injury than their sub-elite counterparts (Dupont et al., 2010). Indeed, a study by Mallo, González, Veiga and Navarro (2011) concluded that a Spanish sub-elite soccer team sustained less major injuries than elite European teams such as those studied by Ekstrand et al., (2011) and Ekstrand (2008). Therefore, it may not be appropriate to use overseas elite injury rate data in an attempt to foresee and understand what may occur at the sub-elite and amateur Australian levels, particularly in the tropics. However, at present there is no injury data to the author’s knowledge on Australian soccer players within the tropics at these levels of competition and thus, this is an area that warrants further investigation.

2.7.6 Injury epidemiology in soccer

The epidemiology of professional soccer has been well documented with numerous studies concluding that elite players are at a high risk of being injured both during training and games (Schwellnus, et al, 2017; Roos, et al, 2016; Stubbe, et al, 2015; Grooms, et al., 2013; Ekstrand, Hagglund & Walden, 2011; Le Gall, Carling & Reilly, 2008 & Jacobson & Tegner, 2007). Literature reports that there are high injury incidence rates during match play in both adult male and females players (Roos, et al, 2016; Hagglund, Walden & Ekstrand, 2011; Le Gall, Carling & Reilly, 2008). Additionally, these match incidences were considered to be much higher than that of their youth counterparts (Jacobson & Tegner, 2007; Le Gall, 2005; Le Gall, Carling & Reilly, 2008). Thus, the suggestion by Faude (2013) that players over 15 years of age are more prone to injuries may prove true when comparing injury incidences during match play.

It has been suggested that a higher training to match ratio can result in decreased injury rates however, this may not always be the case as there are a number of factors that can play a key role in a player getting injured (Le Gall, Carling & Reilly, 2008). These factors can include the location of the injury, type of injury, cause of the injury, how it occurred and the timing of the injury in regards to whether it was during a match or a training session and at what point in time during the season the injury was reported.

Table 2.3 Injury Incidence Epidemiology

Study Division. Country and Gender	Number of Players	Number of Injuries During the Season	Injuries per 1000 hours			Injury Severity (Raw Data (%))				Average Number of Days Lost Due to Injury
			Overall	Training	Games	Minimal/ Mild	Moderate	Severe	Unknown	
Elite Females (Sweden) Jacobson & Tegner (2007)	269	237	4.6	2.7	13.9	92 (39)	92 (39)	52 (22)	0 (0.0)	(-)
Elite Youth Females (France) Le Gall, Carling & Reilly (2008)	110	619	6.4	4.6	22.4	322 (52)	223 (36)	74 (12)	0 (0.0)	18
Elite Males (Numerous European Countries) Ekstrand, Hagglund & Walden (2011)	2251	4483	7.9	(-)	(-)	2135 (48)	1651 (37)	697 (15)	(-)	18

Elite Males (United States) Grooms, et al (2013)	41	13	8.1	4.8	9.6	(-)	(-)	(-)	(-)	291
Elite Males (Netherlands) Stubbe, et al (2015)	217	268	6.2	2.8	32.8	141 (49.3)	98 (34.3)	44 (15.4)	3 (1.0)	8
Elite Males and Females (United States) Roos, et al (2016)	(-)	M: 1554 F: 2271	M: 8.1 F: 8.4	M: 5.5 F: 5.7	M: 17.5 F: 17.0	M: 733 (47.2) F: 1079 (47.5)	M: (-) F: (-)	M: (-) F: (-)	M: 80 (5.1) F: 208 (9.2)	(-)
Elite Males (South Africa) Schwellnus, et al (2017)	(-)	44	2.2	0.9	24.8	11 (25)	12 (27)	10 (22)	0 (0.0)	(-)

(-) Not reported

M Males

F Females

2.7.7 Location of injury

Previous literature reports that the lower extremity locations of the knee, quadriceps and ankle are the most common injury sites in soccer players (Hammes, et al., 2015; Le Gall, Carling & Reilly, 2008; Owen, et al., 2013; Owoeye et al., 2014; Stubbe, et al., 2014; van Beiksterveldt, et al., 2012,). Faude (2013) made similar conclusions stating that up to 90% of injuries in soccer were located at the knee, ankle and thigh sites. In particular, knee injuries such as those to the ACL are common in soccer and preventing them where possible is crucial as they are often deemed to be potentially season or career ending in soccer players (Walden, et al., 2012).

Although it is important to consider the common locations of injuries in soccer overall, it is also essential to consider that these may differ in players depending on their age, gender and level of professionalism.

A comparative study between the injuries sustained in male junior and senior players demonstrated that the most common injury sites were the ankle, knee and upper leg in both age groups (Schmikli, de Vries, Inklaar & Backx, 2011). Similarly, the most common injuries in female soccer players were the same in both junior and senior players with the knee and ACL being injured most often in particular (Steffan, Myklebust, Olsen, Holme & Bahr, 2008).

However, although there may be similarities in the way players of the same gender report injuries, it is important to note that differences may exist between genders In general males and females tend to report similar locations of injury with Yard, et al. (2008) stating that approximately 73% of total injuries occurring in both genders were in the lower extremities. However, the most common locations of injury in females are the ankle and the knee with the latter being of particular interest as it is known that females have an increased incidence of ACL injuries due to factors such as their Q angle (Le Gall, Carling & Reilly, 2008).

In addition to differences between male and female players, there are also differences between the body sites in which differing levels of players are injured. Mallo, González, Veiga and Navarro (2011) reported that lower limb muscular injuries such as quadriceps, calf, hamstrings and hip adductor muscles and knee and ankle joints were the main sites of injury and causes for absence in matches in sub-elite Spanish players. Ekstrand, Hägglund and Waldén (2009) however, reported that hamstrings were by far the more common injury in elite players in a study on 23 of the 50 best European teams selected by Union of European Football Associations (UEFA). Thus, injury site risks must be considered in regards to the level at which players participate in as opposed to applying a ‘one size fits all’ approach.

2.7.8 Type of injury

Although there are various injuries that players may sustain, literature suggests that the most common are soft tissue injuries including strains (in particular strains to the thigh region), sprains, overuse and contusions (Ehrmann, Duncan, Sindhusake, Franzsen & Greene, 2015; Le Gall, Carling & Reilly, 2008; Silvers-Granelli, et al., 2015). In particular, almost one-third of injuries sustained by soccer players are muscle related (Owen, et al., 2013). Specifically, it is also common for players to report muscle strains in the calf region as soccer is deemed to be a high demand sport requiring a lot of speed and power (Askling, Karlsson & Thortensson, 2003). In regards to ankle injuries, overuse injuries are common in especially female soccer players due to the common use of the joint during performance of the sport. Tendinitis and impingement of the ankle are common occurrences, which are encouraged by repetitive movements causing micro trauma and technical errors in kicking and passing (Le Gall, Carling & Reilly, 2008).

2.7.9 Cause of injury

Although the literature states that injuries are caused by multiple modifiable and non-modifiable risk factors, it is estimated that the majority of the time lost due to injury in soccer is due to modifiable risk factors (Alentorn-Geli, et al., 2009; Mendiguchia, Alentorn-Geli & Brugheli, 2012). It is also reported that injuries are most commonly caused by non-contact mechanisms with approximately 59% of injuries contributed to movements such as jumping, kicking and running (Ehrmann, Duncan, Sindhusake, Franzsen & Greene, 2015; Grooms, et al., 2013). Further reasons as to why players may be susceptible to non-contact injuries are lack of flexibility, insufficient warm up, muscle imbalances, neural tension, previous injury, fatigue and muscle weaknesses (Owen, et al., 2013). However, all of these reasons for injury can be prevented by both coaches and players so therefore, it can be questioned that if the majority of injuries can be presumably prevented, what can coaches and players do in order to prevent them. It is also evident in previous literature that junior and youth players may experience injuries more often due from contact mechanisms with reports of over half of the injuries reported due to physical contact with another player (Soderman, Adolphson, Lorentzon & Alfredson, 2001).

Thus, it is important that the age of players be considered when discussing how injuries occur and how best to target injury prevention.

2.7.10 Timing of injury

The timing of an injury can also tell a great deal about the player, his or hers fitness and why the injury may have occurred. Previous literature has stated that the majority of injuries generally occur within the 2nd half of the season with fatigue being a main instigator (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). However, some studies have produced contrasting results such as Le Gall, Carling and Reilly (2008) who stated that the highest proportion of injuries in an elite female team was during the month following pre-season training and the last month of the season actually yielded the lowest number of injuries. Le Gall (2006) reported similar results with the first half of the season producing more injuries in elite French youth male players than later in the season. Players may be most prone to injuries at the beginning of the season due to the introduction of the competitive matches, which are accompanied by higher intensity work and more challenging circumstances. Often, players get injured during this period as they have not yet reached the levels of fitness required and are not at the optimal physiological and physical state to deal with the stresses that may be placed upon them (Le Gall, Carling & Reilly, 2008). It has been suggested that a higher number of injuries towards the end of a season may be the result of higher intensities of play, fatigue and the introduction of highly competitive games during the playoff and finals periods. However, generally younger players such as those at the youth level are not subjected to as high levels of competition and may consequently be at less risk of injury than their older counterparts (Le Gall, Carling & Reilly, 2008). Again, age is to be a key consideration when coaches are deciding how best to implement injury prevention programs.

2.7.11 Injury epidemiology conclusion

Although there has been numerous research studies investigating the common body sites, types, causes and timing of injuries in soccer players, there has been limited research completed on those players within Australia. In particular, there is a lack of literature on injuries in sub-elite and amateur soccer players including injury risks and occurrences within the pre-season and competitive season. Thus, in order to gain an insight into the epidemiology of Australian soccer players, an investigation focusing on these injury factors is required.

2.7.12 Soccer injury prevention programs

Naturally, losing players through injuries both short and long term can be detrimental to a team's success, particularly for those teams at the amateur level as it can be hard to replace players due to limited resources (Arnason, Andersen, Holme, Engebretsen & Bahr, 2008; Owen, et al., 2013). Literature estimates that the majority of the time lost in soccer at the professional level is due to injuries and more often than not, these injuries are due to modifiable risk factors. Consequently, in recent times there have been preventative programs designed for soccer to assist in modifying these risk factors (McHugh, 2009). One such example was a program investigated by Owen et al. (2013), which focused on developing proprioception, strength and core stability in elite male Scottish soccer players. The program provided evidence that a multicomponent injury prevention program performed twice weekly can have a significant impact on improving muscle injury rates, particularly muscle strains and tears (Owen, et al., 2013). Thus, research has suggested that an intervention program can potentially aid in injury prevention. However, the majority of the programs that have been designed generally do not incorporate sport specific components and often require expensive equipment, extensive time and expert personnel to implement successfully. Thus, these types of programs can be difficult for amateur teams to implement and utilise due to the lack of funding and access to qualified S&C personnel (Grooms, et al, 2013).

2.7.13 FIFA 11+ injury prevention program

One injury prevention program that addresses the above limitations is the FIFA 11+ program (also known as the F-MARC 11+ program), which was designed and developed by international and national experts in conjunction with the FIFA Medical and Research Centre. The aim of the FIFA 11+ program is to reduce the incidence of injuries in soccer by specifically training strength, balance, power and neuromuscular control (Al Attar, Soomro, Pappas, Sinclair & Sanders, 2015; Barengo, 2014; Silvers-Granelli, et al., 2015). These exercises mainly focus on the lower body and core muscles as these are the most commonly injured sites in soccer players. Additionally, the 11+ program is designed to be an efficient way of achieving optimal physiological readiness for sport by encouraging activation of the muscles required such as the gluteus medius, gluteus minimus and abdominus (Silvers-Granelli, et al., 2015). The program is designed so that it can be utilised by all levels of players as it requires minimal equipment and can be implemented into regular training sessions with ease by following the simple instructions given (Dvorak, 2005; Dvorak, 2000; Ekstrand, 1983; Grooms, et al, 2013). Additionally, the FIFA 11+ program is deemed to be appropriate for even the most amateur teams as it only requires a soccer ball, takes minimal training and can be completed within a short amount of time. Essentially, the simplicity of the program makes it an attractive alternative to traditional S&C methods that can often be hard to implement and also expensive (Grooms, et al., 2013).

Figure 2.1 FIFA 11+ injury prevention program

The FIFA 11+ program has been found to be very popular in the soccer community worldwide popular due to its high success rates in varying levels of players. The program has been reported to have a success rate of 30-70% among teams from a variety of countries, ages and playing levels (Al Attar, 2015; Barengo, 2014; Soligard, 2010; Steffan, 2013). The program has been reported to be successful in both male and female soccer teams (Grooms, Palmer, Onate, Myer & Grindstaff, 2013; Soligard, et al., 2008; Soligard, et al., 2010).

In particular, the FIFA 11+ program has proven successful in decreasing the rate of injuries to the lower extremity in soccer players and is highly desirable by coaches and players as it has the ability to reduce the risk and severity of knee injuries such as ACL injuries (Silvers, et al., 2014; Walden, et al., 2012). Additionally, Grooms et al. (2013) concluded the program reduced both the severity and risk of injuries to the lower extremity in general in male collegiate players when compared to a control group. Silvers-Granelli, et al. (2015) also reported positive results from using the FIFA 11+ program for injury prevention stating that there was a reduction in injuries of 46% when compared to a control group. The FIFA 11+ program has also shown to be effective in preventing non-contact injuries providing more support as to why it is popular among elite teams (Grooms, et al., 2013).

Additionally, it has been suggested that the FIFA 11+ program is particularly effective in those teams who have a higher number of training sessions per week such as those at the elite or professional level. Completing the program only once per week has been deemed to be too low of a frequency to illicit a physical response in regards to injury prevention (Al Attar, 2015; Hammes, 2015). A systematic review by Barengo (2014) concluded similar results and stated that players who completed the program at least 1.5 times per week reduced injury risk by approximately 35%. Grooms, et al. (2013) also concluded that there was an 82% reduction in lower extremity injuries following the implementation of the FIFA 11+ program five to six times per week. However, in contrast Hammes, et al. (2015) did not report the same positive results from the program due to only training one time per week.

Literature also states that a low compliance combined with minimal training sessions per week that focus on the specific exercises limits the potential impact of the FIFA 11+ program (Al Attar, Silvers-Granelli, et al., 2015; Soomro, Pappas, Sinclair & Sanders, 2015; Steffan, et al., 2013; Steffan et al., 2008). In particular, low levels of compliance with the program have been related to lower levels of effectiveness in preventing lower extremity injuries (Sugiomoto, et al., 2012).

Thus, there is outstanding support for the need of more training sessions per week focusing on the FIFA 11+ program in order for it to be successful.

Another factor that needs to be considered when implementing the FIFA 11+ program is the timing of using it within a training session. To be successful, the program needs to be done at the appropriate time. Originally, the program was designed as a warm up before a training session and this method is still recommended. The rationale behind this timing technique is that the program itself can be utilised as a dynamic warm up. It also offers the potential for better levels of compliance from players as they can perform the program in a less fatigued state prior to completing a training session (Al Attar, Soomro, Pappas, Sinclair & Sanders, 2015).

Therefore, the frequency at which the program is completed by players can be a key influencing factor as to whether the program will be successful or not and needs to be considered when deciding how to implement the program. These points are particularly important to consider when working with amateur teams as they often have less training sessions than their elite counterparts (Bunc & Psotta, 2001).

Although it has been suggested that the FIFA 11+ program is a viable option for injury prevention in amateur teams due to the fact it’s easy to implement and explain, it is still questioned as to whether the FIFA 11+ program has the potential to induce positive benefits for those players who use it less due to time constraints.

2.7.14 Limitations of injury research

Although there have been many studies focusing on injury risk and injury patterns in soccer players, majority of the research has focused on injuries in elite European teams and only a single team or on part of a season (Carling, Orhant & LeGall, 2010; Dauty & Collon, 2010; Ekstrand, Hagglund & Walden, 2011; Hagglund, Walden & Ekstrand, 2005; Stubbe, et al., 2014). Additionally, there has been little published research on injuries in female players in general when compared to that on male players. However, there have been more studies conducted on the impact of an injury prevention program such as the FIFA 11+ program in females than on males (Le Gall, Carling & Reilly, 2008; Silvers-Granelli, et al., 2015). These studies have been completed in a number of countries and continents including the United States, Canada, Europe and Africa (Gatterer, 2012; Grooms, 2013; Hammes, 2015; Junge, 2002; Owoeye, 2014;

Soligard, 2008; Steffan, 2013; Steffan, 2008; van Beijstervedlt, 2012;). Conversely, there have been limited investigations focusing on its use in players in Asian Pacific countries such as Australia. Additionally, it is particularly important to note that as the risk of injuries has been reported to potentially differ between countries, it is not appropriate to utilise overseas research within Australia. Thus, there is a need for research on injuries in Australian soccer players, particularly at the sub-elite and amateur levels (Waldén et al., 2005).

2.8 Environmental Considerations

In addition to factors such as training design and injuries, there is the consideration of differing environmental factors that may play a key role in whether fitness will improve, deteriorate or plateau during the course of a season.

Importantly, it is important to consider how the climate and environment can impact on the fitness and training of players. The tropical climate, such as that in Far North Queensland, Australia, is unique in that instead of the usual four-season pattern seen in other parts of the world, seasons are determined by the movement of the tropical rain belt resulting in a wet and a dry season (Hue, 2011). This climate also consists of humid conditions that are characterized by high temperatures and rainfall that exceeds evapotranspiration for more than two thirds of the year (Hue, 2011). These characteristics can be problematic for athletes and their training should they live in this part of the world. Thus, within this thesis, the term “tropics” refers to the region in which the players live within Australia (Far North Queensland).

2.8.1 The importance of environmental considerations for soccer players in the tropics

In the present day, soccer is played on every continent and with different parts of the world, comes differing climates and environments. When playing soccer in tropical climates such as that in Far North Queensland, Australia, there are a number of environmental characteristics that are unique and must be considered when training. For example, the challenges of playing in the heat were clearly evident during the final game of the 2008 Beijing Olympic Games where temperature reached 42 °C on the field (FIFA, 2009). As both the 2014 Football World Cup and the 2016 Olympic Games were held in Brazil (known for its tropical climate) as well as a number of other major soccer competitions that will be surely held in similar climates including in Australia, it is important that the effect of heat on soccer players be investigated (Hue, 2011).

2.8.2 Tropical environmental characteristics impact on physiological aspects

Players who perform in tropical environments with hot and humid conditions are often subjected to a decrease in performance due to the physiological challenges (Maughan & Shirreffs, 2010; Grantham, et al., 2010). These decrements in performance are generally due to either impairment's in cardiovascular function resulting in a reduction of oxygen delivery, or central nervous system alterations that cause central fatigue (Nybo, 2010). Soccer players in particular are also at risk of suffering from extremely high muscle temperatures (Mohr, et al., 2010), which may result in contractile and neural impairments in muscle function (Grantham, et al., 2010). Players who play and train in hot weather conditions are also occasionally at risk of their body temperature exceeding 40 °C (Mohr, et al., 2010). It is known that deterioration of performance may begin when the environment reaches 12-15 °C, it is evident that players living in tropical climates are at a very high risk (Maughan & Shirreffs, 2010). Evidentially, a combination of the increased body temperatures and fatigue can result in a decrease in performance such as in the distance run and the amount of high intensity running during the second half of a game (Grantham, et al., 2010).

Players in tropical climates are often at risk of severe dehydration due to the hot and humid nature of the environment. It is known that when the temperature of the environment exceeds that of the skin (such as those conditions in tropical climates), heat is inevitably gained. This gain of heat is also in addition to the production of metabolic heat that exists during the performance of exercise and thus, the players are placed under severe physiological heat stress. Although evaporation works to effectively dissipate large amount of heat and can generally ensure the body temperature does not rise more than two to three degrees Celsius in extreme conditions, during a soccer game the temperature can still typically reach 39-40 °C (Maughan & Shirreffs, 2010). This high temperature is more than enough to dehydrate a player and effectively impair their performance. Additionally, the sweat a player produces during a soccer match causes the body to not only lose heat but also electrolytes and sodium, which can further hinder performance particularly in the form of skill and cognition movements (Maughan & Shirreffs, 2010). The body can also be at an increased risk of heat illness and large sodium losses, which may then lead to a risk of muscle cramps (Grantham, et al., 2010; Shirrefs, Sawka & Stone, 2006). Athletes are particularly susceptible to performance decrements if they have a pre-exercise dehydration level of 1.5-2% of body mass or after they perform 30 minutes of repetitive sprints (Maxwell, Mackenzie & Bishop, 2009). Therefore, players within soccer are highly vulnerable due to the 90-minute duration of the game.

Exercising in the heat also increases the player's susceptibility to further physiological deteriorations including a heightened rate of muscle glycogen depletion, higher lactate concentrations and a lower level of blood creatine kinase which can all further reduce performance (Buccheit, et al., 2011; Maughan & Shirreffs, 2010).

Even those players who have lived in tropical conditions for a considerable amount of time and are acclimatized are not immune to the physiological side effects. Although the impacts of high temperatures are reduced, there is still limited protection when humidity is also high as it often is in regions such as Far North Queensland (Maughan & Shirreffs, 2010). Numerous authors have investigated the physiological responses of those acclimated individuals with no definitive conclusion drawn although it is suggested that those who had lived in a tropical climate for more than two years showed a heat tolerance with suppression of sweating which can aid in thermoregulation and the preservation of body fluid (Bae, et al., 2006; Saat, Sirisinghe, Singh and Toichihara, 2005).

Therefore, it is without a doubt that athletes who perform in hot and humid conditions for long periods of time or multiple times per week are subjected to an additional load. It then must be taken into account that in order to prevent overtraining and ensure that recovery is adequate, the climate must be considered for the athlete to improve and progress within their training (Hue, 2011). In order to ensure players are able to perform at their optimal best when exercising in the heat, S&C strategies such as programming considerations must be put into play in an attempt to minimize the adverse effects of hot and humid conditions. For example, it is acknowledged that the first protective mechanism against a player suffering from heat illness, is for the body to reduce the intensity and duration of an activity and thus, this often comes down to how the S&C coach implements the training session (Grantham et al., 2010). This information is vital for coaches who are working with athletes in hot and humid conditions such as that of Far North Queensland to identify so that appropriate planning and program implementation can be considered.

2.8.3 Limitations in research of environmental impact on soccer players in the tropics

It is well documented that in order to reduce physiological strain and gain improvements in the ability to exercise in the heat, a complex set of adaptations must occur resulting in acclimation to the heat (Hue, 2011). However, although there has been extensive research done on the physiological adaptations to exercise in hot and dry climates, little is known on acclimation in hot and humid conditions (Hue, 2011). In addition, the majority of the data collected in these hot and humid conditions has mainly been contributed through investigations that involved using laboratory artifacts such as a tropical climate created in a laboratory conditions. Thus, there is limited research on the physiological responses created due to natural conditions or during outdoor testing conditions (Hue, 2011).

In particular, the implications of extreme environmental conditions on the performance and health of soccer players has been given limited attention due to the sport originally being begun as winter spot in regions of North Europe (Maughan & Shirreffs, 2010). Although severe heat stress appears to be less common in soccer players than those who play other sports, the need for research on the effect of heat on them in regards to fitness changes is still required, particularly in those in Australia.

2.9 Summary

Although there has been previous research on fitness changes throughout a season in soccer players, the majority of this research has been conducted in countries within Europe and North America. There is a need for more investigations into the seasonal variations in fitness in soccer players within Australia, particularly in tropical climates such as that of Far North Queensland, due to the different physiological responses players may have in these environmental conditions. This potential knowledge will assist those S&C and sports coaches within these areas in programming and implementing training for soccer players both within the pre- and competitive seasons.

3. Seasonal variations in fitness in female soccer players: the use of small sided games for fitness

The use of SSG to improve soccer fitness has been well reported. However, the effectiveness of this type of training and success to simulate sport specific fitness has been questioned, particularly at the amateur level. Additionally, although there has been some research conducted on SSG use in Australian sport, the majority of these studies have focused on players at the elite level of sport such as those in sporting academies. The purpose of this study was to determine whether soccer training mainly comprised of SSG's was appropriate for increasing and maintaining fitness throughout the season for sub-elite female players in Australia.

Hervert, S.R., Deakin, G.B. & Sinclair, K. *Science of Sport, Exercise and Physical Activity in the Tropics.* Seasonal variations in fitness for female soccer players: The use of small sided games for fitness. Eds A. Edwards & A. Leicht. Nova Scientific, USA. 2014.

3.1 Introduction

The aim of both professional and semi-professional soccer players is to acquire and maintain seasonal fitness enabling them to play at an elite level (Caldwell & Peters, 2009). However, there are distinct differences in the way in which a professional athlete trains compared to an amateur. A professional player has the opportunity to train three to four times per week and can accumulate approximately 14 hours of training time during the regular season. In contrast, an amateur or sub-elite player will generally only train two to three times per week for a maximum of six hours. Additionally, professional athletes undertake off season training to maintain acquired fitness from season to season while amateur athletes do not typically participate in any regulated off season training and often start the new season with only a basic foundation level of fitness (Bunc & Psotta, 2001).

A number of research studies have examined the influence of training three to six times per week on seasonal fitness in soccer players and have shown inconclusive evidence that player fitness improves throughout the season (Clark, Edwards, Morton & Butterly, 2008;

Ellingsgaard & Bangsbo, 2005; Hoff & Helgerud, 2004; Krustrup, Mohr, Maclaren, et al., 1988; Mereer, Gleeson & Mitchell, 1997). Whilst there is some evidence that fitness variables such as aerobic and anaerobic performance can be improved during the competitive season with regular team training sessions there is also evidence indicating a deterioration from or maintenance only of acquired pre-season fitness following in-season training (Clark, Edwards, Morton & Butterly, 2008; Hoff & Helgerud, 2004; Krustrup, Mohr, Ellingsgaard &Bangsbo, 2005; Maclaren, et al., 1988; Mercer, Gleeson & Mitchell, 1997). It seems that without players being progressively stimulated during the competitive season physiological variables such as aerobic fitness can deteriorate and vertical jump (VJ), speed and agility performance can plateau from the mid-season point onwards (Clark, Edwards, Morton & Butterly, 2008). The lack of consistent improvement in seasonal fitness amongst soccer players may be attributed to the style of training being employed in the modern era.

Whilst soccer coaches and teams often experiment with different training techniques in an attempt to address the fitness concerns of athletes, the utilization of the Dutch model of training has become increasingly more popular with professional and elite teams in recent years (Gabbett & Mulvey, 2008; Metaxas, Sendelides, Koutlianos & Mandroukas, 2006). The Dutch model of training involves an extensive amount of ball work in the form of SSG with little focus on specific conditioning for soccer (Junge & Dvorak, 2004). There has been literary support to suggest that this form of training can help to improve agility and motor coordination due to the nature of SSG requiring constant changes in direction (Magal, Smith, Dyer & Hoffman, 2009; Reilly & Bangsbo, 1998). However, this model of training has also been questioned due to the lack of specific conditioning involved particularly amongst non-professional player groups (Enisler, 2005; Reilly, Clarys & Stibbe, 1993; Reilly & Thomas, 1980; Reilly & White, 2005). Due to professional athletes generally being employed full time to train, additional specific conditioning is not an issue with separate training sessions targeting specific fitness attributes being implemented within their weekly training schedule (e.g. strength and power sessions). However, amateur players including developmental squads and academies are also using SSG to train players and improve footwork. Unfortunately, as amateur players do not have the same training opportunities as professionals, the effectiveness of this technique is questionable due to limited time available to train. The lack of time spent on physical conditioning and progressive overload offered by SSG may prevent the development of basic functional attributes required for soccer such as strength, power, speed, agility and flexibility (Cook, 1998).

Although seasonal variations in fitness of soccer players have been researched, the majority of literature has focused on male soccer players in European regions (Engstrom, Johansson & Törnkvist, 1991). Consequently, there is limited research on their Australian counterparts and in particular, female youth players in the tropics. Past literature has also generally focused on seasonal variations in fitness of players for the entire duration of the competitive season with testing commonly occurring pre- and post-season only. However, little research has been completed focusing on what happens during the first half of the season. Therefore, the purpose of this study is to determine whether the use of SSG is an appropriate training technique to acquire and maintain fitness throughout first half of the season in semi-elite female youth soccer players.

3.2 Methods

Thirteen semi-elite female youth soccer players (age: 15.0±0.89 years, height: 1.63±0.05m, body mass: 54.9±5.0kg) who competed in the 2013 season of the Far North Queensland Premiere Ladies division participated in the study. The team played in competitive games from March through to September however this study focused on the first half of the season (i.e. the first 9 weeks). All players provided written inform consent before participating in the study and all methods were approved by the Institutional Ethics Committee.

Players attended two testing blocks consisting of two test sessions. The first testing block was after the cessation of pre-season training and the second at the mid-point of the season. The first testing session had players perform a battery of tests including anthropometric (height, body mass and body fat percentage) and fitness (trunk flexibility, upper and lower body power, agility, sprint speed and aerobic capacity) tests, in the order listed. The second testing session was held seven days later and entailed players performing an intermittent recovery test. Players undertook a standardized 10 minute soccer specific warm up before completing each testing session. All testing sessions were held at the same time of day at the same location.

Prior to the warm-up in the first testing session, height, body mass and body fat percentage were measured using a stadiometer and Tanita scales, respectively. Trunk and hip flexibility were assessed using a standardized S&R box whilst lower body power in the form of VJ height was assessed utilizing a Swift Performance yard stick. Each player was instructed to perform a maximal countermovement jump (CMJ) from a standing position and height was measured to the nearest centimetre. An overhead medicine ball throw (OHT) using a standard soccer throw in technique was used to asses upper body power. This required both feet to be placed together and remain on the ground throughout the throw whilst the hands started from behind the head. Players completed the test with a 3 kilogram medicine ball. The horizontal distance the ball travelled was recorded in metres using a tape measure placed along the ground. The power tests selected for this study were chosen due to the movement patterns being directly related to movements performed in soccer games such as jumping to head the ball and throwing a ball in (Cook, 1998). Players also completed a 505 agility test and a 40 metre sprint both with and without the ball. A distance of 40 metres was chosen as soccer players will generally not cover more than this during a single sprint (Sassi, Reilly & Impellizzeri, 2005). Both the sprint and agility tests were timed using Speedlight V2 timing lights (Swift Performance, Australia). For all tests with the ball the players were instructed to keep the ball under control at all times. All players performed three trials of each of the flexibility, power, sprint and agility tests with the best score for each being used for reporting purposes. Aerobic capacity was tested using a Multistage Fitness Test (MSFT) (MSFT, Australian Sports Commission, Australia) with players instructed to complete the test until exhaustion with the respective level and shuttle obtained recorded. The MSFT was chosen as it has proven to be a successful predictor of VO_2 max.

Testing session two required all players to participate in an intermittent recovery test with the respective acquired stage recorded. The Level 1 Yoyo Intermittent Recovery Test (YYIR1) was selected as it has been shown to be a reliable tool to estimate aerobic recovery ability (Katis & Kellis, 2009; Krustrup & Bangsbo, 2001; Krustrup, Mohr & Amtrup, 2005).

Training session structure and player attendance information was also collected each week for the duration of the study. Training session structure data was classified according to the components of training undertaken during that training session (i.e. conditioning, skills or tactics). The results were then expressed as a percentage of total training time for the first half of the season. All data was reported as mean ± standard deviation. Paired t-tests were used to determine if there were any significant differences between the pre- and mid-season anthropometric and fitness performance measures. The alpha level was set at 0.05. Statistical analyse was performed on SPSS for Windows (Version 19, Chicago, IL).

3.3 Results

Of the 12 anthropometric and fitness tests that were performed, VJ height was the only variable that showed a significant change from the beginning to mid-point of the season, decreasing by approximately 18% (Table 3.1). No significant change in any of the remaining anthropometric or fitness variables were found from the beginning to mid-season (Table 3.1).

Table 3.1 Mean (±SD) anthropometric characteristics and fitness performance variables of 13 female youth soccer players from pre to mid-season.

Variable	Pre-season	Post-season
Height (cm)	1.76±0.03	1.78±0.05
Body mass (kg)	75.7±8.62	76.5±8.30
Body fat percentage (%)	14.5±2.75	12.0±3.67
S&R (cm)	11.45±7.95	11.33±6.98
VJ (cm)	70.18±13.28	58.00±4.41*
OHT (m)	9.01±0.94	8.12±1.02
505 agility without the ball (s)	2.16±0.09	2.24±0.06
505 agility with the ball (s)	2.75±0.14	2.94±0.13
40m sprint without the ball (s)	5.50±0.17	5.55±0.18
40m sprint with the ball (s)	6.22±0.36	6.20±0.35
MSFT estimated VO_{2max} (ml/kg/min)	40.21±1.59	44.29±1.29
YYIR1 estimated VO_{2max} (ml/kg/min)	51.28±1.07	52.92±1.57
YYIR1 distance (m)	440±197	560±250

* indicates significant difference from pre-season trial ($P<0.05$).

During the nine weeks of competitive season training, the team reported training a total of 28 hours. Of this time, there was 12.5 hours (44%) of skills focused training and 15.8 hours (56%) of tactical training with no time spent on specific conditioning training at all.

3.4 Discussion

The main finding of this study was that skill and tactical based conditioning via the use of SSG did not improve the fitness of amateur female youth soccer players during the first half of the 2013 competitive season. Lower body power was significantly decreased from pre- to mid-season with the average VJ performance decreasing during the nine-week period of the study. Overall, the results showed a plateau or deterioration in player fitness during the season. Whilst there may be a number of reasons that contributed to the lack of improvement following 9 weeks of SSG training, the greatest contributor would appear to be the lack of specific conditioning training completed during the team training sessions with all focus being placed on ball work. Player attendance was also found to be a reason contributing to the lack of improvement in player fitness. These findings have implications for fitness training as demonstrated by the results of this study as well as the development of players.

Following mid-season testing, a significant deterioration in VJ was reported showing a loss in lower body power by the team during the nine-week period. Even though a deterioration in VJ performance has been reported previously over the course of a season, the deterioration in performance was found mid- to post-season when player fatigue typically begins to set in from a long season (Caldwell & Peters, 2009). Furthermore there was a significant improvement during the first half of the season (Caldwell & Peters, 2009). The authors attributed the increase in lower body power to the inclusion of two weeks of basic and functional strength training within the team during the first half of the season (Caldwell & Peters, 2009). A similar finding has also been reported by other researchers after observing improved VJ performance during a soccer season when weight training and plyometrics training were regularly included in training sessions (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). The deterioration in VJ power in the current study can be explained by the lack of strength and power training within the team sessions. The use of SSG does not specifically target these attributes subsequently these attributes are going untrained throughout the season. This scenario may also explain why the remaining fitness measures including sprinting speed, agility, upper body power and aerobic capacity had no significant improvement from pre- to mid-season.

The finding of a lack of improvement in aerobic capacity of the players during a season has been reported previously. Metaxas, Sendelides, Koutlianos and Mandroukas (2006) found no significant improvement in the aerobic capacity of under 19 male soccer players during the season. In comparison, Kalapotharakos, Ziogas and Tokmakidis (2004) found a significant improvement in VO_2max from pre-season to mid-season in a team of elite professional men. However, as the team was considered to be of an elite level, training six days a week and undertaking soccer specific conditioning training such as aerobic training, explosive strength training and speed training, it becomes evident that players who are given specific conditioning sessions and drills targeting selected fitness variables, are more likely to see an improvement in fitness during the season than those who do not.

In order to target soccer specific fitness, the literature has indicated that match fitness and readiness can be trained through the use of playing SSG (Krustrup, Mohr, Ellingsgaard & Bangsbo, 2005; Metaxas, Sendelides, Koutlianos & Mandroukas, 2006). However, if the time utilising this model is when the sole fitness training of the team occurs, then it is possible that a "repeat bout effect" could occur during the season causing the athlete to plateau in performance due to the training stimulus not being progressive. The undertaking of SSG week in, week out doesn't necessarily mean players are being physically challenged leading to improved fitness adaptation. Although many coaches believe that ball work is the most important aspect to consider when designing training sessions, it is necessary to consider the possible consequences involved with this model. A repercussion of limited conditioning training is that there is inadequate opportunity for the development of functional movement abilities such as power, strength, speed and agility. Variables such as these are important as they provide the underlying basis for the sport performance movements important in soccer including heading the ball and directional changes in movement (Cook, 1998). Additionally, a lack of conditioning may also result in imbalances and weaknesses in the body, which has been reported to lead to an increase in injuries, a scenario that may well have played a part in the current study. It was found that over the duration of the study, the team had a total of 15 training sessions (Kalapotharakos, Ziogas & Tokmakidis, 2011). Over this time, there were five injuries reported resulting in players missing valuable training time. Furthermore, as the team consisted of representative players who had additional soccer and sporting commitments throughout the season, a number of training sessions were lost due these commitments or traveling away for representative competition. Consequently, the combination of injuries and other commitments resulted in some players missing approximately half of the 15 scheduled training sessions (i.e. 50% of training time available).

The most notable point to come from the analysis of the training component data was that there was no specific conditioning training undertaken by the team. The coaches stated that focus on skills and tactics was of most importance and that the Dutch model of training was utilised at all times due to the belief that it would enhance player's ball work and control resulting in better play by players. Additionally, there was no known fitness training periodization implemented during the sessions but rather periodization of the players' skill aspects to increase focus on ball work skills, tactics and game strategies. However, there are a number of problems that can arise from 100% ball work and ball focused training. In order to increase the fitness of an athlete, a new stimulus must be continually offered to allow for overload and adaptation to occur (Gabbett & Mulvey, 2008). If constant focus is on the ball and tactical components during each training session, it can be hard to monitor and increase the intensity of the work being performed due to the player's concentration being on the ball. This lack of intensity leads to the players undertraining in terms of their physical ability and therefore, fitness is not improved.

It is also worth noting that the majority of past soccer research into seasonal fitness has been completed using data collected from the entire season but given that the current study has shown that fitness is not improving in the first half of the season and may even be deteriorating in some cases, more research is needed to determine what occurs with player fitness during the first half of the season and what can be done to optimise fitness during the initial weeks of the competitive season.

3.5 Conclusion

The findings of this study indicate that including SSG (as seen in the use of the Dutch model) is not an adequate training technique for seasonal improvements in the fitness of semi-elite youth female soccer players. This form of training was found to produce no significant improvements in anthropometric and physiological performance measures over the course of the first nine weeks of the season. Although skill and tactical based training is important for player development, soccer specific physical conditioning is required if athletes intend to acquire, maintain and improve fitness following pre-season training. If there are insufficient training sessions available for the team to accommodate a fitness conditioning component, additional training drills may need to be performed by players away from the designated team tactical and skill focused sessions. Additionally, factors such as attendance and injuries can also have a major impact on a player’s fitness due to time availability to train and need to be taken into consideration when implementing the Dutch model of training.

4: Does skill only conditioning help improve physiological and functional fitness in amateur soccer players?

As Chapter 3 demonstrated, SSG training was not an adequate form of training for improving and maintaining fitness in youth soccer players. However, this Chapter focused on the effects of SSG training female players on changes in physiological fitness during the season only. Thus, Chapter 4 will investigate whether SSG training can help improve both physiological and functional fitness in amateur female soccer players. Additionally, as a lack in functional fitness has been linked to injury susceptibility, the project also aims to identify the impact SSG has on functional ability.

Hervert, S.R., Deakin, G.B. & Sinclair, K. (2013). Does skill only conditioning help improve physiological and functional fitness in amateur soccer players? *Journal of Australian Strength and Conditioning.* Journal of Australian Strength and Conditioning Supplement 2 | 2013 Conference Proceedings, 34-36.

4.1 Introduction

Acquiring and maintaining seasonal fitness is a priority amongst soccer players who strive to play at a professional or elite level (Caldwell & Peters, 2009). This level of fitness is maintained by participating in games and training a minimum of three to four times per week for a total of approximately twelve to fourteen hours (Cometti, Maffiuletti, Pousson, Chatard & Maffulli, 2000). These athletes also participate in off-season training aimed at maintaining the majority of the fitness gains acquired during the competitive season (Bunc & Psotta, 2001). Comparatively, amateur soccer players generally undertake limited off-season training and subsequently, any acquired fitness from the previous season tends to deteriorate over the off-season period, essentially requiring them to begin again from the foundation level. Whilst the seasonal fitness changes of professional male players particularly in Europe is well known, less is known about players in Australia, particularly females and youths. Further research in this area is needed as playing soccer in a European winter is substantially different to playing in an Australian winter and even more so if based in Far North Queensland (Caldwell & Peters, 2009; Engstrom, Johansson & Törnkvist, 2011).

An important factor that has been known to impact on seasonal variations in fitness is the type of training that athletes undertake during the season. In the modern era, an increasing number of professional and elite teams are using the Dutch model of training to improve the players' ball skills and soccer specific fitness (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011; Reilly & Bangsbo, 1998). The model entails an extensive amount of ball work with minimal time spent working on fitness aspects alone (Katis & Kellis, 2009). While this model helps in developing better footwork and ball control, the benefits in terms of increasing physiological fitness has been questioned due to the lack of conditioning intensity to stress the required physiological systems (Reilly & Thomas, 1980). Professional athletes typically use the Dutch model in conjunction with separate conditioning training sessions and therefore, the players are able to maintain their fitness during the season.

Amateur players including those from developmental academy squads are also beginning to adopt the Dutch model of training (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). However, unlike their professional counterparts, many of the players within these amateur teams are adolescents, often only training 2-3 times per week for approximately 4-6 hours (Cometti, Maffiuletti, Pousson, Chatard & Maffulli, 2000). Given the limited training time available per week and the focus on skill rather than fitness under the Dutch model of training, this model of training may not be the most effective way to develop a young players' fitness capacity. As the Dutch model entails players participating in SSG (consisting of teams of three to five) on a reduced pitch (eg. Ranging from 5 x 5m to half the pitch), this model of training may also prevent players from developing basic functional abilities such as mobility, flexibility and balance due to limited movement (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011; Cook, 1998). If a player focuses on only one aspect of performance, they may lose the fundamental movement patterns they possess as part of normal growth (Cook, 1998). However, there is limited research on the functional ability or fitness characteristics of young players over the course of a season to determine if the use of the Dutch model of training is beneficial to their sporting development.

The aim of this study was to determine if skill based training (use of the ball in each task) improves physiological and functional performance measures in amateur adolescent female soccer players over the course of a season.

4.2 Methods

Twelve female players from a local amateur soccer academy team (age 15.0±0.89 years, height 1.63±0.05m, body mass 54.9±5.0kg) volunteered to partake in this study. The team competed in the 2013 season of the FNQ Premiere Ladies division from March to September. The Institutional ethics committee approved all procedures within the study and each player signed an informed consent prior to commencing.

Players attended the testing session at the same time of day at the beginning and end of the competitive season. Following a 10 minute standardised warm-up the players performed two functional tests (squat and shoulder flexibility) and two power tests (VJ and OHT) before completing a MSFT. The functional and power tests were selected because of their direct involvement with movements undertaken in soccer such as running, jumping to head the ball and throwing the ball in. The functional squat test was performed as previously described and involved completing a full range squatting movement whilst holding a bar overhead at arm's length (Cook, 1998). An adequate performance consisted of a squat through the full range of motion with heels flat on the ground and the arms straight above the head. Knees were also required to track over the toes without deviation to the side. If a player demonstrated a perfect squat, they were awarded a score of three points. However, if there was an issue with the squat such as the heels lifting off the ground, then only two points was given. One point was scored if more than one problem arose with the squat and if the individual felt any pain during the procedure, the attempt was give zero points. Players then performed an over-under flexibility test using both the right and left arms. The procedure involved the player reaching around behind the body and placing one hand between the shoulder blades with the palm facing out. The opposite arm was then straightened above the body with the elbow bent to allow the hand to hang behind the head. The player was then instructed to attempt to touch the fingers of both hands together. The distance between the hands (scored positive if hands were able to touch and negative if they did not) was then measured to the nearest centimetre. Both tests were carried out by testers experienced with functional movement testing.

A Swift Performance Yardstick was used to measure VJ height. Players were instructed to perform a jump for maximal height using a counter movement jump and height was measured to the nearest centimetre. For the other head throw, players were instructed to stand with their feet together and perform a standard soccer throw in using a three-kilogram medicine ball. The horizontal distance the ball travelled was recorded to the nearest centimetre using a measuring tape that was placed along the ground. Players performed three trials for all the functional and power tests with the best trial of each recorded for reporting purposes. The team then completed the standard MSFT as a group and were instructed to work until exhaustion. The maximum level and shuttle reached by each player was recorded. Additionally, information on the teams training sessions was collected weekly throughout the season from the coaches including the time spent on the training components; 1) Conditioning fitness drills (no ball work), 2) Skills, ball passing, SSG and shooting drills, and 3) Tactics incorporating team and/or player strategizing and formation practice. The total percentage of time spent on each training component over the season from pre to post-testing was calculated.

All data are expressed as mean ± standard deviation. Paired t-tests were utilised to determine any significant changes between the beginning and end of season time points for each performance measure. The alpha level was set at 0.05.

4.3 Results

Of the four tests performed, VJ was the only variable to show a significant change, a deterioration of 21% over the course of the season. No significant differences were found between pre- and post-testing for any other functional or physiological fitness characteristics.

Table 4.1 Functional and physiological fitness characteristics of 12 female soccer players from pre and post-season.

Characteristic	Mean ± SD	
	Pre	Post
Right arm under-over (cm)	7.85 ± 3.99	10.75 ± 5.22
Left arm under-over (cm)	5.6 ± 3.17	7.2 ± 4.61
Functional squat (score)	1.92 ± 0.51	1.82 ± 0.75
VJ (cm)	47.7 ± 11.50	37.7 ± 4.01*
OHT (m)	4.63 ± 0.50	4.51 ± 0.48
MSFT (level.shuttle)	8.1 ± 1.59	9.0 ± 1.36

* indicates significant difference from pre-season trial ($P<0.05$)

In respect of the team's training components, over half of the training time was spent on tactical training (53%) while the remaining time (47%) focused on skills training. No specific conditioning training was conducted throughout the season.

4.4 Discussion

The aim of this study was to determine if skill based training (use of the ball in each task) improves physiological and functional performance measures in amateur adolescent female soccer players over the course of a season. The major finding of this study was that skill based conditioning did not improve any of the physiological or functional abilities of the players over the course of the season and in the case of lower body power production, significantly reduced VJ performance. Additionally, the study also indicated that all of the training the players undertook throughout the season, there was no specific conditioning training at all, with all the focus on skills and tactics.

The data collected throughout the season indicates that over half the training implemented consisted of tactical training while skills practice made up the remaining time. The ball was included in 100% of the training the players completed as it was deemed an essential component of all drills and formation work by the coaching staff. It was also indicated by the coaching staff that they believed ball skill development to be crucial for the players as they are young and still in the learning process. Whilst this may be true, the results indicate that the players' fitness and functional movement abilities did not improve and even deteriorated as was the case for the VJ. It has been suggested that this model of training may not be suitable if an increase in fitness during the season is desired and the results of the current study support this point. Although ball work is an important component of training in soccer it should not necessarily be the main focus of every session (Clemente, Couceiro, Martins & Mendes, 2012).

One of the issues with the continued use of the ball in training is that it is hard to monitor intensity let alone increase it. To increase fitness an athlete is required to participate in training that is continuously offering a new stimulus (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). The skill based model of training does not appear to offer is due to the continued use of the ball during every session decreasing the intensity of work as concentration is focused on the ball rather than on working to full physical capacity. This lack of intensity and progression leaves the players under training in terms of physical ability thus, not improving their fitness.

The lack of specific fitness conditioning throughout the season also has implications for developing the functional movement abilities of players, which are the underlying basis of sporting performance. It is important that the functional components of fitness such as flexibility are maintained in order for the body to be able to perform more complex movements such as those found in the game of soccer (Cook, 1998). Although under-over flexibility did show some limited improvement, though not significant, the functional squat performance did not. The less than perfect squat scores for the majority of the team in the current study indicated notable room for improvement. As the lower body is used more so than the upper body during soccer, it should be the main focus of training for improvement as with the study in question.

In conclusion, skill based training does not improve the physiological and functional performance measures in amateur adolescent female soccer players over the course of a season due to the focus being purely on skills and tactics.

4.5 Practical Applications

This study indicates that a lack of fitness conditioning training provided by the use of skill and tactics orientated training only (as seen with the use of the Dutch model), can result in a plateau or a deterioration in fitness and functional ability in amateur soccer players over the course of the season. Even though skill based training may be appropriate for recovery and tactical training, incorporating more specific physical conditioning without the use of a ball is required if the intention is to improve or maintain seasonal fitness levels. If there are insufficient team sessions available to accommodate this, then additional training sessions or drills for players to perform away from the designated team skill and tactic sessions should be provided.

5: A comparison between the seasonal fitness of adolescent male and female soccer players

Although Chapter 4 concluded that SSG may not be appropriate for training physiological and functional fitness in female soccer players, there is still a lack in research on the seasonal variations in fitness in youth male and female soccer players at the sub-elite level, particularly in Australia. Additionally, more investigation is needed on the factors other than SSG training that may influence seasonal variations in fitness such as attendance and injuries of players through a competitive season. Thus, this chapter addresses the lack of research on seasonal variations in fitness in soccer players within Australia, and in particular, those at the youth level of competition. It aims to address differences in seasonal fitness changes between male and female players and in addition, establish the factors, which contribute to the outcome such as player injury rates, training/game attendance and training session structure.

5.1 Introduction

Pre-season training aims to prepare players for the competitive season and rebuild fitness following the off-season (Jeong, et al., 2011). The goal of in-season training is to maintain that level of fitness during the season (Bangsbo, 1993; Reilly, 2007). Numerous studies have investigated soccer conditioning in adults and shown that seasonal fitness changes throughout the season. Some fitness characteristics have been shown to improve such as aerobic and anaerobic performance whilst others including lower body power, speed and agility have been shown to decline during the season (Caldwell & Peters, 2009; Magal, Smith, Dyer & Hoffman, 2009). Characteristics in some studies however, have shown no change over the course of the season such as aerobic performance (Kalapothrakos, Ziogas & Tokmakidis, 2011).

Although all soccer players require the same fitness characteristics to perform successfully, there are differences between genders in how they play the game (Sporis, Jukic, Ostojic & Milanovic, 2009). It has been reported that adult males cover approximately 33% more distance at a high intensity than females at the elite level (Krustrup, Mohr & Bangsbo, 2005). Additionally, differences in the nature of game play exist with elite males having slightly less rest time with a work to rest ratio of 1:12 compared to 1:13 for females (Arnason, et al., 2004; Gabbett & Mulvey, 2008). Furthermore, variances also exist between adolescent and adult players. These differences have been found to influence the game play of individual players depending upon which category they fall in to. Junior players for example, work at a slightly slower game pace in comparison to their adult counterparts with a work to rest ratio of 1:15 (Bangsbo, Nørregaard & Thorsoe, 1991; Gabbett & Mulvey, 2008).

Research in seasonal fitness in soccer has focused primarily on elite European adults players. However, with junior participation increasing with the introduction of developmental programs and academies, investigation is needed on how the training and fitness of male and female adolescent players differ to their gender and older counterparts, particularly in other regions of the world. To assist in addressing weaknesses that may prevent optimal seasonal fitness, identification of key influencing factors is needed. Factors that have been identified previously in adult players as influencing seasonal fitness are injuries, training/game attendance and the training used for conditioning (Caldwell & Peters, 2009; Kelly & Drust, 2009; Quatman-Yates, Myer, Ford & Hewett, 2013; Soderman, Adolphson, Lorentzo & Alfredson, 2001). However, the influence of all these factors on adolescent player's seasonal fitness is relatively unknown.

Traditionally, training sessions are divided into conditioning, skills and tactical components (Jones & Drust, 2007). However, professional adult and adolescent players have recently started to focus on maximising skill and tactical training using SSG to develop and maintain seasonal fitness. Consequently, there has been a decrease in the time spent on physical and sport specific conditioning particularly during training sessions (Rampinini, et al., 2007). Although SSG have been shown to improve skill development, they generally only work at increasing fitness when periodised appropriately (Eniseler, 2005; Gamble, 2004). Thus, Gabbett and Mulvey (2008) suggest that to improve fitness, SSG be used in conjunction with physical conditioning. As elite soccer players have a higher number of training sessions per week and additional S&C sessions the use of SSG may not be appropriate for adolescent players (Bunc & Psotta, 2001; Sporis, Jukic, Ostojic & Milanovic, 2009). The effectiveness of focusing on SSG at the expense of physical conditioning in the training of youth soccer players is questioned and requires further research.

Therefore, the aim of this study was to determine the variations in fitness in youth female and male soccer players throughout the course of a competitive season. In addition, investigate what factors contributed to the outcome by examining player injury rates, training/game attendance and training session structure.

5.2 Methods

5.2.1 Experimental Approach to the Problem

The study was conducted on two youth regional soccer teams that participated in the 2013 Australian winter season competition, which ran from March until September. The year was broken up into pre-competition (January to March) and competitive season (March-September) with fitness testing for this study occurring at pre- (March), mid- (June) and post-season (September).

All players completed the same battery of tests at pre- and post-season. The test battery was split across two test sessions to limit the impact of fatigue from all the tests being completed on the same day. The players performed a standardised 10minute warm up which consisted of a slow jog followed by dynamic leg stretches and varying paced sprints. The warm up protocol was familiar to players as it included similar exercises to those performed at training sessions and games. The same warm-up protocol was performed prior to each subsequent test session.

Immediately prior to the commencement of the first test session all players' height, body mass and body fat percentage were recorded using a stadiometer and electronic scales that were accurate to two decimal places. The first test session consisted of both generic and soccer specific tests including upper and lower body flexibility and power, agility and speed with and without the ball. The second test session was held after a 48-hour recovery period and involved the completion of the Level 1 Yo-Yo Intermittent Recovery Test (YYIR1). All test sessions were held at the same time of the day (early evening) to control for circadian rhythm variations. The flexibility, power, agility and speed tests were all performed three times with the best trials recorded for reporting purposes.

Additionally, player injury incidence, training and game attendance, and training session structure (i.e. the time allocated to conditioning, tactical and skill training components) were collected over the course of the season. Coaches were required to record player attendance and training component data each training and game day for collection each week by the principal investigator. Injury documents were completed for each injury suffered by a player and collected by the principal investigator each week.

5.2.2 Subjects

Twelve female and fourteen male youth soccer players from the same club participated in the study. The physical characteristics of the female and male players are outlined in Table 1. The two teams were members of a North Queensland soccer academy participating in a regional competition during the 2013 Australian season.

Prior to participation in the study all players were informed of the procedures of the study and signed an informed consent document. The study was approved by the James Cook University Human Ethics Committee.

Table 5.1 Physical characteristics of the youth female and male soccer players

Group	Age (y)	Height (m)	Body Mass (kg)	Predicted Vo_{2max}*
Females (n=12)	15.58±0.8	1.63±0.05	54.95±5.02	39.87±1.66
Males (n=14)	15.94±0.2	1.75±0.06	67.10±10.77	43.79±2.87

* *Vo_{2max} values* are estimated according to the YYIR1 results

5.2.3 Procedures

5.2.3.1 Fitness Testing Battery

Anthropometric Characteristics

Height, body mass and body fat percentage were obtained using a stadiometer and electronic digital scales (Tanita, Kewdale, Australia), respectively. Electronic scales were utilised as they were deemed to be the easiest method to implement with adolescent players at the location of a soccer field. Additionally, there was no access to a DEXA scanner within the region.

Flexibility

Hamstring, trunk and hip joint flexibility were assessed using the standard S&R test (Sporis, Jukic, Ostojic & Milanovic, 2009).

Power Development

Upper body power was assessed by players performing an overhead medicine ball throw using a three-kilogram medicine ball. Previously, a backward OHT test has been utilised to test power production in college football players however the test was altered to be more soccer specific by using a forward OHT to replicate a soccer throw in (Mayhew, et al., 2005). Players were instructed to stand with feet together and perform a standard soccer throw in. A throw was considered to be adequate if it adhered to the following criteria: no movement of the feet, no arching of the back and the ball being released from behind the head with two hands. The distance the ball travelled was recorded to the nearest centimetre using a measuring tape that was placed along the ground. Lower body power was assessed using a Yard Stick (Swift Performance, Lismore, Australia) VJ device. Following the recording of starting height, players were asked to perform a maximal countermovement VJ with the final jump height recorded to the nearest centimetre.

Agility and Speed

Both the 505 Agility test and 40 meter sprint tests were completed using electronic timing gates (Swift Performance, Lismore, Australia). A 505 Agility test was used to assess agility performance as it has previously been utilised successfully to identify the skills and fitness in soccer players (Hoare & Warr, 2000). For the test, players were asked to accelerate at maximum speed, run through a set of timing gates placed at the 10 metre mark and then continue another 5 metres to a set of cones before turning using their dominant foot and running back 5 metres through the gates. Time was recorded to the nearest 0.01 seconds. Following the completion of the three trials, players were then required to perform three more trials, but this time with a ball. Players were asked to turn with the ball using the outside of their dominant foot and to keep it as close to their body to allow for the quickest time possible.

Speed was assessed with the performance of a 40-metre sprint over a straight course. The distance of 40 metres was used as this was deemed to be the maximum distance that players will generally sprint within a game. Additionally, this distance has been used previously to test RSA in soccer (Impellizzeri, et al., 2008). Players were instructed to start with one foot at the starting line and to run at maximum speed through timing gates, which were set up at 40 metres. Sprint times were recorded to the nearest 0.01 seconds. After the completion of three trials without the ball, players repeated the sprint test with a ball to simulate a game scenario (Sayers, Sayers & Binkley, 2008). Players were instructed to keep the ball close to the body and dribble it through the timing gates at maximum pace. Players were given approximately two to four minutes between trials to allow for sufficient recovery.

Intermittent Recovery Test

Having identified that soccer requires a good level of aerobic capacity and the ability to perform intense intermittent exercise, it is imperative that an appropriate test be used to measure this variable appropriately (Sayers, Sayers & Binkley, 2008). Consequently, intermittent recovery performance was assessed using the YYIR1 (Krustrup, et al., 2003; Sayers, Sayers & Binkley, 2008). As both the male and female teams were considered to be of an amateur level and categorised as youth, the Level 1 test was deemed appropriate for all players within the study.

5.2.3.2 Attendance Data

Coaches of both the female and male teams collected attendance data for all training sessions and games throughout the season. Data was collected each week outlining the attendance of each player. Coaches were asked to specify the reason for an individual missing a training session or game, using the following specifications: 1) Injury 2) Sickness 3) Other (which included absence due to personal reasons, study or work commitments).

5.2.3.3 Training Session Structure

To evaluate the organisation of weekly training sessions, each individual session was divided into specific sub components as determined by the type of training being undertaken. Conditioning was deemed to be any fitness training including sprints and the use of agility poles with and without the ball (Foran, 2001). When training was scheduled to have a focus on ball drills or shooting practice the session was considered to be skills training. Tactical training was considered to be any session time allocated to team or player strategy practice such as formation practice. Subsequently, coaches were asked to provide a time allocation for the following training components: 1) Conditioning 2) Tactical 3) Skills. Additionally, the total duration of each training session was collected via the total number of minutes (ie. the total of the training allocation minutes) as well as the average rate of perceived exertion (RPE) for each training session. The structure of individual training sessions was collected from the coaches each week via the use of allocated forms.

5.2.3.4 Injuries

Injury data forms were completed each time a player suffered an injury. A player was deemed to be injured if they got hurt in any way that prevented them from performing a training session or game at 100% ability, or any physical complaint irrespective of time lost from physical activity or the medical attention (Fuller, et al., 2006). The player and/or coach were then required to complete the given form and return to the principal investigator. The form required statements such as how and the place of where the injury occurred, injury type and severity, the number of training sessions and/or games missed due to the injury and the body site that was injured to be recorded (Gabbett, 2003).

5.2.4 Statistical Analyses

5.2.4.1 Fitness Data

Results are presented as mean ± standard deviation. Paired t-tests were performed to evaluate differences between pre- and post-season data for both males and females and individual t-tests were used to determine the differences within genders. Statistical significance was set at an alpha level of 0.05. All data were analysed using SPSS Version 20.

Although T-test is relatively robust to violation of normality and variability of the variance, calculations that were not presented in the paper, the small number of subjects in the sample raises considerable doubts about the accuracy of the results and its conclusions

5.2.4.2 Attendance, Training Component and Injury Data

Attendance is presented as a percentage of total number of both attended and missed training sessions. The average number of missed training sessions and games per player was also calculated as follows:

$$\frac{\text{Total number of team training sessions and/or games missed}}{\text{Number of players in team}}$$

Training component data is presented as a percentage of total training time (eg. 25 minutes is equivalent to 22.5% of a 90 minute training session).

Injuries are presented as per 1000 training and playing hours and were calculated as follows (20):

$$\frac{\text{Number of injuries}}{\text{Total exposure hours}} \times 1000$$

Total exposure hours were calculated as:

[(Total number of training sessions x number of minutes per training session) + (Total number of games x 90 minutes)] x number of players in team

5.3 Results

One participant from the female team and three participants from the male team did not complete the required testing sessions and therefore, were omitted from statistical analyses for seasonal fitness. Additionally, although mid-season data was collected, the results were not included in analysis as majority of players did not perform testing at all three time points with mid-season being the most prominent time point missed.

5.3.2 Fitness Testing Battery

There was minimal improvement in both the youth male and female fitness from pre- to post-season with the majority of fitness variables showing no improvement over the course of the competitive season (Table 5.2). However, there was a significant difference in pre- and post-season between the male and female teams in all variables except S&R and VJ at preseason and S&R at post season. Although jump performance deteriorated in the female team, there was no significant change for males. The females also performed significantly worse in both the agility with and without the ball at post-season testing however the males showed no change. Both the male and females improved significantly in the YYIR1.

Table 5.2 Pre to post-season mean (±SD) anthropometric and fitness performance variables of youth male and female soccer players

	Youth Males		Youth Females	
	Preseason	Postseason	Preseason	Postseason
Height (m)	1.75±0.06	1.75±0.06	1.63±0.05#	1.63±0.04#
Weight (kg)	67.09±10.77	67.99±11.34	54.95±5.20#	56.61±6.42#
Body Fat %	13.95±3.94	14.39±5.41	23.47±3.80#	24.23±3.29#
S&R (cm)	10.33±6.41	8.58±8.16	8.13±3.65	8.55±4.58
VJ (cm)	50.23±4.97	58.71±15.54	46.30±10.95	36.90±3.19*#
OHT (m)	6.67±1.19	6.61±0.87	4.61±0.53#	4.46±0.51#
505 Agility (s)	2.25±0.12	2.19±0.06	2.51±0.11#	2.61±0.13*#
505 Agility with Ball (s)	2.97±0.21	2.96±0.27	3.43±0.14#	3.61±0.22*#
40m Sprint (s)	5.81±0.34	5.66±0.31	7.96±0.59#	6.61±0.31#
40m Sprint with Ball (s)	6.84±0.40	6.57±0.64	7.96±0.59#	7.39±0.59#
YYIR1 Distance (m)	873.3±339.3	1275.0±294.3*	413.3±198.0#	702.9±193.0*#
YYIR1 Vo_{2max}	43.79±2.87	47.11±2.47*	39.87±1.66#	42.30±1.62*#

* indicates significant difference from preseason result

# indicates significant difference to youth males at the same time point eg. Preseason or postseason

5.3.3 Attendance Data

There was a similar game and training attendance rate between males and females with only a 1% difference between the two teams (Table 5.3). However, the male team had an additional four training sessions compared to the females during the season. The male team missed nine times more training sessions due to injuries and over five times more due to sickness than females. The females however had 97 missed trainings explained as "Other" while the males had only 37 in comparison.

Table 5.3 Youth male and female soccer player's game and training attendance (percentage) and contributing factors (injury, sickness etc)

	Youth Females	**Youth Males**
Number of Total Season Trainings	33	37
Average Number of Attended Training (SD)	23.8 (5.4)*	31.6 (9.0)*
Average Number of Unattended Training (SD)	9.15 (5.4)*	11.4 (8.9)*
Average Percentage of Attended Trainings	76.3	71.5
Average Percentage of Unattended Trainings	23.7	28.5
Number of Total Team Missed Trainings Attributed to Variables		
Injury	13	101
Sickness	5	26
Other	97	37

* significantly difference between number of attended vs. unattended training

5.3.4 Training Session Structure

The female team participated in no specific conditioning training throughout the season whilst in comparison the male team allocated 41% of training time to conditioning (Table 5.4). The female team also spent over half the training time on tactical components while the males focused on tactical slightly less (34%) with the remainder of the time on skills training. This lack of conditioning time in the female team is also evident in the lower average RPE score of 7.03 compared to 7.73 in their male counterparts. Although the male team had a higher number of training sessions (37 compared to 33), they actually completed a lower number of total minutes than the female team (2765 compared to 3425). Consequently, the average number of training minutes per training sessions was also less in males than females at 69.13 and 103.78 minutes respectively (Table 5.4).

Table 5.4 Percentage of training sessions of youth male and youth female soccer players as divided into training components 1) Conditioning, 2) Skills and 3) Tactical and training durations and intensity (RPE)

		Youth Females	Youth Males
Percentage of Training session spent on component	Conditioning	0	41
	Skills	47	25
	Tactical	53	34
Training duration and intensity	Total training minutes	3425	2765
	Average training time minutes	103.78	69.13
	Average training RPE	7.03	7.73

5.3.5 Injuries

Both the males and females recorded less injuries during games than in training sessions (Table 5.5). Majority of the injuries sustained by both the males and females occurred on the lower half of the body with over half of the injuries reported affecting the knees, quadriceps, ankles and calves. Although the site of injury was similar between genders, males suffered twice as many injuries as females in the lower half of the body. Both teams suffered the majority of injuries during the first half of the season (Table 5.6).

Table 5.5 Characteristics of injuries according to occurrence and body site (Injuries expressed as per 1000 exposure hours)

Injury Information	Youth Females	Youth Males
Occurred in Game	2.14	3.66
Occurred in Training	11.78	14.29
Head	0	1
Arms	1	1
Torso	2	1
Knees	2	3
Quadriceps	1	1
Ankles	2	5
Calves	0	5
Hamstring	0	0
Hip	0	1
Injuries per 1000 Exposure Hours	7.53	4.80

Table 5.6 Injury occurrence during the season

	Youth Females	Youth Males
Injuries during 1st half of the season (Total %)	7 (87.5)	15 (83)
Injuries during 2nd half of the season (Total (%)	1 (12.5)	3 (17)

5.4 Discussion

The aim of the current study was to determine the variations in fitness over the course of a competitive season in youth male and female soccer players as well as conclude how injury rates, training and game attendance and training session structure contributed to any variations that occurred. There were minimal improvements in fitness in both the male and female soccer teams throughout the season. However, the males were shown to perform significantly better than females in majority of the fitness variables at both pre and post season testing. Additionally, the males also recorded more injuries and performed more specific conditioning training than their female counterparts throughout the season.

At the preseason fitness testing, there was a significant difference between the males and females in all fitness variables with males performing better in all assessments except VJ and S&R. As the preseason testing was conducted prior to any substantial training being undertaken by either team, the difference in physical performance could be attributed to gender characteristics such as males generally being stronger than females (Brukner & Khan, 2012). However, the differences in physical performance between males and females still existed at post season testing with the addition of a significant difference in VJ. The males also performed 181% and 159% better than the females in the YYIR1 and VJ test respectively. These results are similar to those presented by Mujika, Santisteban, Impellizzeri and Castagna (2009) which also showed junior males performing significantly better than junior females in a variety of variables including agility, speed with and without the ball and also performed 153% and 56% better than the females in the YYIR1 and countermovement jump respectively.

The difference (though small and limited to a few variables only) in seasonal fitness between the female and male teams may be attributed to the lack of intensity of effort by the female team throughout the season. Additionally, the lower RPE score of the female team suggests that they did indeed perform training at a lower intensity than their male counterparts. Although the males performed better at post season testing compared to their female counterparts, the conditioning training still could have been designed better by including more specific conditioning without the ball (as majority of the conditioning was with the ball) as the athletes still only improved significantly in one variable (YYIR1) when compared to their own preseason results. It is also important to consider that there is an explosive power difference that exists between males and females, particularly at youth level while participants are still adolescents (Rampinini, et al., 2007). Additionally, this difference can be due to differences in maturation during the teenage years between genders with males often developing power and strength at a quicker rate than females. The female team also reported an increase in weight during the season and this may have affected some of the fitness results such as the VJ. Therefore, it can be suggested that coaches and players may also need to take into consideration explosive power training techniques that are specific to the gender of the athletes when designing training sessions.

In addition to performing significantly worse in VJ power at the end of the season, the female team also diminished in both the performance of the 505 Agility test with and without the ball. The males however, maintained their performance throughout the season. The male and female post-season agility performances are comparatively different to that found in a study by Mujika, Santisteban and Castagna (2009) who found junior males and females had no significant differences in a 15m Agility test. The differences in VJ power and agility between genders in the current study could be explained by the approaches taken by the individual coaches to the individual training session design of the teams and the variance in total number of training hours. The male team spent 41% of the time on conditioning training compared to the female team who did not participate in any specific conditioning throughout the season. This lack of focus on conditioning in the female team can be attributed to the majority of training sessions having an emphasis on activities utilising the ball. Although the males had an extra four training sessions during the competitive season, the female team reported more total training minutes and thus, exposed players to more training time. However, the female team did not include any conditioning training. Conversely, the male team did include both specific conditioning and game related (skill and tactical) training incorporated into sessions.

Although there were differences in majority of the fitness performances between genders, both female and male players improved significantly in the YYIR1 from pre- to post season. It is suggested that this improvement in the YYIR1 may be attributed to the game fitness that the players may have gained throughout the season. As the YYIR1 is designed to simulate a game situation, any game related fitness that was gained throughout the season will assist with a more successful performance in the test (Ingebrigstsen, et al., 2012). It is also evident that as the male team completed more conditioning training during the season than the female team, gender focus may not be the only influencing factor on fitness.

Soccer, like any sport, possesses a risk of injuries in both training and games and occurrence of these throughout a season can have a detrimental effect on player’s fitness (Yard, et al, 2008). Over the course of the 2013 season, the male and female teams recorded a total of 18 and 8 injuries respectively. As the male team had more training sessions throughout the year it could be expected that they would experience more injuries than the females. However, in contrast, majority of literature states that females are more prone to being injured due to their anatomical make up (Eniseler, 2005). There have been many studies focusing on the injury incidence of both male and female soccer players with some paying particular attention to youth athletes (Knowles, et al., 2006; Yard, et al., 2008). Yard et al. (2008) for example, concluded that over the course of two seasons (2005-2006 and 2006-2007), girls sustained 51.6% of the overall soccer-related injuries recorded in a study focusing on injuries of male and female high school students. 65% of the reported injuries in females occurred during competition rather than during training. In comparison, males suffered 55% of injuries during competition (Yard, et al., 2008). Knowles et al., (2006) however, concluded that there was a higher injury incidence during training than within competition for both genders. The current study disagreed with majority of past literature as it was found that the female injuries accounted for less than a third of total injuries suffered by both teams throughout the season and majority of injuries occurred during training sessions rather than games in both genders. The female players in this study may have recorded less injuries than their male counterparts as they may have trained at a lower intensity than the male team because of the intent use of ball-only training, and were thus presented to less injury prone circumstances (for example, softer impacts from tackles). The lower average RPE intensity recorded by the female team also supports this suggestion.

Interestingly, past literature has stated that female soccer athletes presented 14.3 injuries per 1000 match hours and male athletes reported 16.2 injuries per 1000 match hours (Junge, Dvorak, Graf-Baumann & Peterson, 2004; Ostenberg & Roos, 2000). It is evident that the current youth players reported lower rates of injury risk per 1000 match hours compared to current literature with values of 4.80 for the males and 7.53 for the females. However, there is a disparity between the risk of injury during training hours between the present study and previous research with rates of 14.29 and 11.78 for males and females in the current athletes compared with 3.70 for both males and females (Junge, Dvorak, Graf-Baumann & Peterson, 2004; Ostenberg & Roos, 2000).

One reason for the contrast between the present studies injury rates and that of previous literature is that the current teams also entered the season and pre-season testing after only undertaking limited pre-season training and over 80% of all injuries occurred during the first half of the season. In comparison, majority of literature has shown that most injuries occur during the 2nd half of the season (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). Due to the high percentage of injuries that occurred during the first half of the season and also during training sessions, it is evident that more time needs to be focused on conditioning during the off-season. This will allow for an adequate foundation level of fitness prior to the start of the season to avoid and manage injuries as proficiently as possible.

Injury sites between the male and female participants also differed slightly in the current study with injuries in the lower extremities accounting for 62.5% for the males total injury count compared to 83.6% for the females. In comparison, Yard et al., (2008) concluded that both genders suffered similar injury rates with both males and females recording 73% of total injuries occurring in the lower extremities. Males recorded five times more injuries to the calf region than their female counterparts with girls suffering no injuries to this area. Additionally, in the current study neither males nor females recorded any injuries to the hamstrings. This is considered to be unusual as muscle strains to this region are common in sports that have a high demand of speed and power such as soccer (Askling, Karlsson & Thortensson, 2003). Injuries such as muscle strains in the hamstrings, quadriceps or calves that were sustained during training may have been due to an inadequate warm up by the players prior to the session. In order to prevent such injuries occurring, an appropriate warm up such as the FIFA 11+ program should be utilised (Junge, et al., 2010).

Furthermore, it is important to identify that there are a variety of mechanisms that can affect the injury risk among soccer players (Koutures, 2010). In outdoor soccer in particular, shoe characteristics and playing surfaces have an important impact on injury rates (Emery & Meeuwisse, 2006). Uneven field surface conditions can lead to excessive load being placed on the ligaments, muscles and joints of players which may result in inadequate landing after jumping (Koutures, 2010). Inappropriate footwear can also cause an increase in lower extremity injury risk due to too much or too little frictional force (Wong & Hong, 2005). However, these mechanisms seemed to play a limited role in the current study as majority of injuries in both teams were caused by contact with another person by means of being tackled, making a tack or a collision. This finding supports similar research conclusions by Soderman, Adolphson, Lorentzon and Alfredson, (2001) who stated that over half of the traumatic injuries sustained by youth players were due to physical contact with another player.

Due to the injuries suffered by both teams throughout the season, players missed a number of training sessions and/or games and thus, fitness and training opportunities during the year. Females missed more training sessions during the season than the males with each individual missing an average of 2.58 trainings and 0.46 games in total compared to only 0.4 trainings and no games for males. The females were therefore, exposed to less training hours than the males and had less opportunity to improve on not only fitness but also skills within the game. Less exposure to training may have also had implications on the female's VJ and agility results as they may have performed worse than the males at post-season testing due to the difference in total training hours. In addition, the females participated in no specific conditioning training throughout the season and instead, focused on SSG training which accounted for 47% of training sessions. In contrast, the youth males only spent 25% of time on skills training allowing more time to focus on conditioning. It is evident that the females may have been disadvantaged in attempting to maintain or improve fitness due to the limited time allowed to train fitness variables appropriately.

Casajus (2001) states that the length of the season may also influence the outcome of post-season results. Athletes of sports such as soccer that have a particularly long competitive season of up to eight or nine months, often find it hard to maintain an optimal level of fitness throughout (Casajus, 2001). The current team's season ran for a total of approximately seven months and therefore, athletes may have been experiencing fatigue during post-season testing and their performance may have therefore been hampered. As the length of the season is out of the investigators control, it is suggested for future research that the coaches and players of youth soccer teams try to counteract fatigue levels as much as possible by undertaking appropriate recovery methods.

In conclusion, the differences between the fitness results of the female and male teams could exist due to a number of factors including variances in injuries, attendance and/or training status. Although a primary focus on skills and tactics within training sessions (for example, SSG) can help in the development of game play in youth players, it is suggested that there be training time set aside specifically for conditioning without the ball to focus on the conditioning of players alone. To assist with the prevention of injuries during the season, a S&C program that is soccer specific should be utilised not only during pre-season but also throughout the season. By implementing this type of training that is aimed at increasing and maintaining fitness throughout the season, coaches would be allowing athletes to not only have the opportunity to become fitter and stronger, but also to be less prone to injuries and therefore, attend more training sessions and games.

6: The effect of a soccer specific conditioning intervention on injury rates in an Australian sub-elite team

Due to the limited improvements in fitness and the additional concern of high injury risks that were reported in Chapter 5, it was determined that a soccer specific conditioning program could be implemented to assist in potentially improving seasonal fitness and reducing injuries in sub-elite soccer players. As the previous chapters have discussed the potential negative impacts injuries can have on fitness and attendance throughout a season, it is important to investigate whether a S&C program can reduce these effects in sub-elite soccer players. Thus, this chapter aims to address the utilization of a soccer specific S&C program in sub-elite male soccer players in Australia. Additionally, this chapter will also determine whether such a program can in fact decrease injury rates and discuss any barriers that may arise with the programs implementation.

6.1 Introduction

Soccer is considered to be the most popular sport played with the International Federation of Football Association (FIFA) stating that approximately 270 million people play worldwide (FIFA, 2007). However, similar to the majority of sports, soccer presents an injury risk for players at all levels of competition including both professional and amateur groups (Junge, 2004). Faude (2013) suggests that as age increases, so does the rate of injuries with approximately 15 to 20 injuries per 1000 hours of match play in those soccer players over 15 years of age. In a systematic review on injuries in male international soccer players by Junge & Dvorak (2004), it was reported that approximately 10 to 35 and 2 to 7 injuries per 1000 hours of match play and training occurred respectively. Additionally, majority of injuries in soccer affect the lower extremity and are a result of noncontact mechanisms. Often, these injuries are considered to be severe (20% of the time) and require 10 or more days to recover resulting in time lost from activity (Grooms, et al., 2013). Consequently, Grooms et al. (2013) estimates that the majority of time lost in soccer at the professional level is due to injuries and frequently these injuries are due to modifiable risk factors such as a lack in flexibility, insufficient warm up and fatigue. In recent times preventive programs have been introduced into soccer to assist in modifying these risk factors (McHugh, 2009). However, many of the programs designed to prevent injury do not incorporate sport specific components and require expert personnel, expensive equipment and extensive time in order to be effective thus making it difficult for amateur teams to utilise them (Grooms, et al., 2013).

One example of an injury prevention program that addresses the aforementioned limitations is the FIFA 11+ program, which was developed by national and international experts in conjunction with the FIFA Medical and Research Centre. The FIFA 11+ program aims to reduce the incidence of football injuries, requires minimal equipment and can be easily implemented as a part of regular soccer training sessions (Grooms, et al., 2013; Dvorak, 2005; Dvorak, 2000; Ekstrand, 1983). The program has been shown to have a success rate of 30-70% in teams at a variety of playing levels, countries and ages (Al Attar, Soomro, Pappas, Sinclair & Sanders, 2015; Barengo, 2014; Soligard, 2010; Steffan, 2013). Grooms et al. (2013) concluded that the program also reduced the overall severity and risk of injuries to the lower extremity when compared to a control group in collegiate male soccer players. The FIFA 11+ program is considered to be suitable for all levels of players as it only requires a soccer ball, can be completed within a short time frame and takes minimal training. The simplicity of the program allows it to become an attractive alternative to traditional S&C methods that can be expensive and hard to implement (Grooms, et al., 2013).

The FIFA 11+ program is designed to train specific strength, power, balance and neuromuscular control for soccer players and in addition, aims to reduce injury rates (Al Attar, Soomro, Pappas, Sinclair & Sanders, 2015). The program has been found to be effective in male soccer players (in particular at the elite level) and it has been suggested that it has more potential benefits for those teams who have a higher number of trainings per week such as those at the professional and elite level. For example, Grooms et al. (2013) concluded that an 82% reduction in lower extremity injuries occurred in collegiate players following performance of the 11+ program five to six times per week. In contrast, Hammes et al. (2015) did not report the same benefits of the program with veteran players due to only performing the program once per week. Additionally, it has been suggested that a low compliance combined with minimal sessions per week focusing on the 11+ program often limits the potential impact of the program (Al Attar, Soomro, Pappas, Sinclair & Sanders, 2015). As sub-elite and amateur teams such as that in Hammes et al (2015) study often have a limited number of training sessions per week when compared to elite teams, it is questioned as to whether the 11+ program has the same positive benefits for those players who utilise it less due to time restraints as it does at the higher level of competition (Bunc & Psotta, 2001).

Previous research has focused on the effectiveness of the FIFA 11+ program in countries throughout Europe and Africa, United States and Canada (Gatterer, 2012; Grooms, 2013; Hammes, 2015; Junge, 2002; Soligard, 2008; Steffan, 2013; Steffan, 2008; Owoeye, 2014; van Beijstervedlt, 2012). However, no studies have investigated the programs use in Australia. Additionally, there has been minimal research on the effect of a soccer specific S&C intervention on the injury rates in a sub-elite team, particularly in Australia. Thus, the aim of this study was to analyse the effectiveness of using the FIFA 11+ program in conjunction with a soccer specific S&C program in preventing injuries in sub-elite Australian male soccer players.

6.2 Methods and Materials

The study was conducted on a regional men's soccer team that participated in an Australian winter season during March until September in 2013 and 2014. All players had been selected during trials at the beginning of the 2013 and 2014 season and were deemed to be of a sub-elite level. The years consisted of pre-competition (January to March) and competitive season (March-September) periods. Additionally, as the team participated in a State League competition, players were required to travel throughout the state for games.

6.2.1 Study Design

During the 2013 season, the investigator conducted an observation of injuries, attendance and game results on a weekly basis. During the 2014 season, the investigator implemented a soccer specific S&C program in conjunction with the FIFA 11+ injury intervention program. Injury data, attendance and game results were again collected on a weekly basis during the 2014 season.

6.2.2 Subjects

Thirty male amateur soccer players from a regional Australian team participated in the study. Although the team changed from year to year dependent on team selection, the core group remained the same in both seasons. There were 11 players who participated in both the 2013 and 2014 season and completed the study. Prior to participating in the study players were explained in detail the circumstances under which the investigation would take place and both the risks and benefits of completing the study. Each player also completed a medical history questionnaire and gave written informed consent. The study was approved by the James Cook University Human Ethics Committee.

Table 6.1 Characteristics of Australian Male Sub Elite Soccer Players

Year	Group	Age (y)	Height (m)	Weight (kg)	Predicted Vo_{2max}*
2013	Males (n=16)	21.42±3.42	1.75±0.03	72.14±6.60	54.80±6.26
2014	Males (n=25)	22.47±3.49	1.80±0.06	77.39±76.70	68.66±9.73

* $Vo_{2max\ values}$ are according to pre-season MSFT results

6.2.3 Intervention

The training year was divided into a pre-season period that lasted for eight weeks in both the 2013 and 2014 seasons and the competitive season, which lasted for 21 weeks and 26 weeks respectively. Due to time and coaching constraints, there was approximately 30 minutes total per week allocated to S&C training during the competitive season. No training was done prior to this time as the investigator did not have access to the teams during the preseason. During this time allocation, both the FIFA 11+ program and the S&C program were implemented.

In regards to strength and proprioception training, the FIFA 11+ program was utilised as it has been deemed an appropriate method of training lower body and core strength as well as preventing injuries (Al Attar, et al., 2015; Barengo et al., 2014; Silvers-Granelli, et al., 2015).

The 10-15 minute program was performed on-field, did not require any equipment and involved 15 exercises which were divided into three components; 1) running with change of direction 2) strength, plyometric and balance 3) running with warm down. Overall, the FIFA 11+ program included exercises that focused on eccentric training of the thigh muscles, plyometric drills that encouraged good alignment in posture, core stabilization, dynamic stabilization and proprioceptive training (Barengo, 2014).

Each exercise had three varying degrees of difficulty that were increased according to individual and team progression (Al Attar, et al., 2015; Barengo, et al., 2014 Silvers-Granelli, et al., 2015). The FIFA 11+ program was implemented and led by the primary investigator who also facilitated in correcting technique each session and provided progressions for the program as needed. As the program has been deemed appropriate to be used at the beginning of the session, it was integrated into the warm up at the start of training sessions (Hammes, et al., 2015). Additionally, as adherence is known to be a key factor in the level of success of the FIFA 11+ program, every player in the team performed the exercises unless injured (Hammes, et al., 2015; Soligard, et al., 2010).

In addition to the FIFA 11+ program, a soccer specific S&C program was also implemented during each session. The exercises included a number of core and lower body strength exercises such as squats, lunges and plyometric jumps and abdominal and core focused drills. Furthermore, a number of upper body exercises including push-ups were also incorporated to encourage full body conditioning.

Throughout this study, the FIFA 11+ program and specific S&C programs were combined and are presented as “FIFA 11+ S&C”.

6.2.3.1 Injury Data

Injury data forms were completed by the investigator each time a player was deemed to have an injury. An injury was defined as anything physical that prevented the player from performing a training session or game at 100% capacity, or any physical complaint irrespective of time lost from physical activity or the medical attention given (Fuller et al, 2006). The injury form consisted of information regarding how and location of where the injury occurred, injury severity and type, the number of games and/or training sessions that were missed due to the injury and the body site of the injury (Gabbett, 2003).

6.2.3.2 Attendance Data

The coach and primary investigator collected attendance data at weekly training sessions and determined when players missed a training session due to injury.

6.2.3.3 Game Outcomes

The outcomes from each game were recorded as either a win, loss or draw. Additionally, total goal difference was calculated at the end of the season. All game outcomes and goal differences were taken from regular competitive season games excluding any games in pre-season or during the finals series at the end of the season.

6.2.4 Statistical Analyses

Injuries are presented as either raw data or per 1000 training and playing hours which were calculated as follows (Phillips, 2000):

$$\frac{\text{Number of injuries}}{\text{Total exposure hours}} \times 1000$$

Total exposure hours were calculated as follows:

[(Total number of training sessions x number of minutes per training session) + (Total number of games x 90 minutes)] x number of players in team

Attendance data are calculated as percentages of attendance and non-attendance. These percentages are reported regarding overall team attendance performance.

6.3 Results

Injury rates during the 2013 and 2014 seasons are shown in Table 6.2. Although the 2013 team reported fewer injuries than the 2014 team (21 and 26 injuries respectively) and thus had a lower injuries per 1000 exposure hours, it was found that the severity of the injuries were less following the intervention. This is demonstrated by the decrease in total days lost due to injury from 214 during the observational year to 99 in the intervention year. There was found to be a similarity between the seasons with the majority of injuries in both years occurring during matches as opposed to training sessions. Additionally, despite there being more match hours during the 2014 season, the injuries per 1000 match hours decreased by approximately 16%. In contrast, there was a small increase in the injuries per 1000 training hours of 0.72. Although the majority of the injuries were sustained in the lower extremity in both seasons, it was found that following the intervention there were improvements in the respective injury incidence per 1000 exposure hours and per 1000 match hours. There was also a notable decrease in the number of days lost due to lower extremity injuries from 156 to 67 days. However, there was a slight increase in the rate of injuries per 1000 training hours from 0.6 to 1.4.

There was no change in the number of non-contact injuries or those in the lower extremity caused by unknown circumstances between the two seasons. However, reflective of the increase in total number of injuries, there was an increase of contact injuries in both the whole body and lower extremity in the 2014 season when compared to the 2013 season with three more injuries in both circumstances. Despite the increases in all other types of injuries (muscle, bruise and other), there was a decrease in those injuries due to ligament damage.

Table 6.2 Comparison of whole body and lower body injury rate between 2013 and 2014 seasons

	Whole Body		Lower Extremity	
Variable	**Observation (2013)**	**Intervention (2014)**	**Observation (2013)**	**Intervention (2014)**
Total number of sessions	1080	1440		
Total exposure hours (trainings + games)	2017.5	2710		
Injury incidence/ 1000 hours	10.4	18.1	8.43	7.38
Match hours	427.5	510		
Training hours	1590	2200		
Match injuries	19	19	16	15
Training injuries	1	3	1	3
Other Injuries (Work, non-sport specific surgery)	1	4	0	2
Injuries/ 1000 match hours	44.4	37.3	37.4	29.4
Injuries/ 1000 training hours	0.6	1.4	0.6	1.4

Days lost	214	99	149	64
Injury Mechanism				
Contact	12	15	9	12
Non-Contact	7	7	6	6
Cause Unknown	2	4	2	2
Type				
Bone (eg. Fracture)	1	1	0	1
Muscle (eg. Strain/Sprain/Tear)	11	13	9	11
Ligament	7	4	6	3
Bruise	2	5	2	5
Other	0	3	0	0
Total number of injuries	**21**	**26**	**17**	**20**

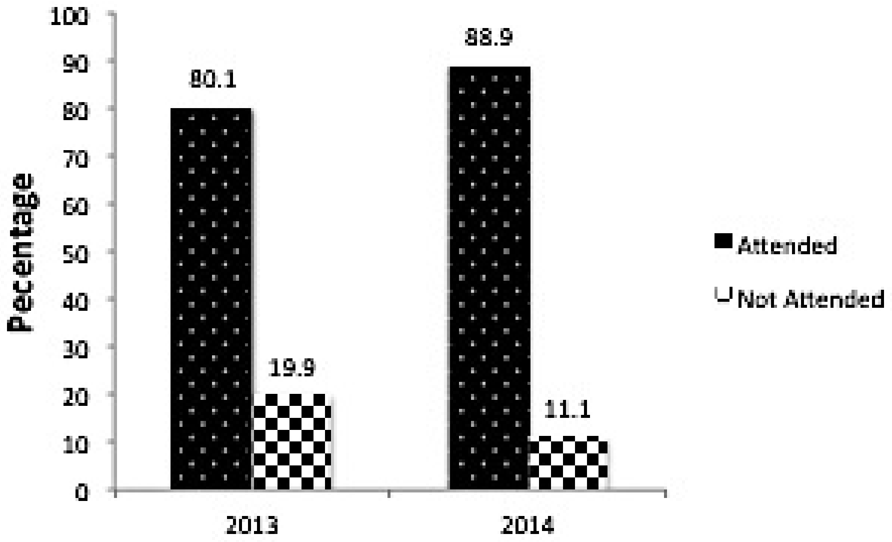
The lower extremity proved to be the most common location for injuries in both the 2013 and 2014 season as shown in Table 6.3. The most notable difference between seasons was the decrease in the total days lost due to injuries such as those to the knees which reported a decrease from 85 days in 2013 to 7 days lost during the 2014 season. Additionally, reports of hamstring injuries also decreased and although there were a higher number of ankle injuries in 2014, there were less days lost suggesting they were much less severe.

Table 6.3 Comparison of injury location and time lost due to lower extremity injury between 2013 and 2014 seasons

Specific injury incidence	**Number of Injuries Recorded**		**Number of Days Lost Due to Injury**	
	2013	2014	2013	2014
Hip	0	0	0	0
Hamstrings	2	0	16	0
Quadriceps	4	5	16	25
Groin	0	2	0	0
Knee	7	4	85	7
Lower leg (calf/shin)	1	2	0	5
Ankle	3	6	32	19
Foot/Toe	0	1	0	8
Total	**17**	**20**	**149**	**64**

Attendance rates (Figure 6.1) differed slightly between the 2013 observational and 2014 intervention seasons. There was an improvement in overall team attendance in the intervention season with an increase from 80.1% to 88.9%.

Figure 6.1 Attendance rates during the 2013 season vs. 2014 season expressed as a percentage (%)



The 2014 season produced better results in terms of games won as there was an improvement from four wins to fifteen wins during the intervention season (Table 6.4). Additionally, it was also found that there was an improvement in the goal difference score at the end of the season with an increase from -38 to + 16 goals.

Table 6.4 Comparison of game outcomes during the 2013 and 2014 Seasons

	2013	**2014**
Goals For	30	64
Goals Against	68	48
Total:	**(-38)**	**(+16)**
Wins	4	15
Draws	1	3
Losses	17	8
Total Games:	**22**	**26**
Final Ladder Place:	**10**	**2**

**Please note: figures are only for games prior to post season testing and excluding final*

6.4 Discussion

The aim of the study was to determine the effectiveness of a FIFA 11+ S&C program in preventing injuries in sub-elite soccer players within Australia. The FIFA 11+ S&C program was implemented throughout the competitive season in the intervention season and assisted in decreasing the severity of injuries to the lower extremity. The days lost due to injuries also decreased following the intervention and the team performed more successfully in terms of games won, goals scored and overall placing at the end of the season.

As injuries are a often a common factor influencing team performance, it is useful to analyse injury outcomes during the seasons to determine if the use of soccer specific conditioning has any effect on injury rates and severity. Although the observational season had a lower injury rate per 1000 exposure hours, the severity of the injuries was higher as indicated by the total days lost due to injury when compared to the intervention season (214 and 99 days respectively). This indicates that the FIFA 11+ S&C program may have assisted in reducing the severity of injuries during the 2014 intervention season. The number of days lost due to lower extremity injuries was effectively decreased by approximately 43% following the intervention. Similarly, Grooms et al. (2013) also reported a decrease in the severity of lower extremity injuries following use of the program in collegiate male soccer players. As decreasing time lost due to injury is considered to be an important aspect of conditioning to coaches and players, improvements such as in the current study are desirable and can encourage support of using the FIFA 11+ S&C program.

The most common area of the body that was injured was the lower extremity with over 78% of injuries occurring on this site in both the observational and intervention seasons. The current data supports previous literature by showing that lower extremity locations such as the knee, ankle and quadriceps are the most common injury sites (Hammes, et al., 2015; Owoeye, et al., 2014; van Beiksterveldt, et al., 2012). This finding is consistent with prior research by Faude (2013) who reported that up to 90% of injuries were located at the ankle, knee or thigh sites. Although the rate of ankle injuries did not decrease in the current study, it is important to note that the total number of days lost due to ankle injuries was lower in 2014 representing the lower severities also recorded.

The rate of quadriceps injuries also increased in the 2014 season when compared to the previous year, however one player accounted for 60% of the time lost due to reporting re-injury twice due to returning to play too early without full recovery. The investigator however, had no control over when players returned to sport following injuries, as it was left up to coach and player discretion. Thus, re-injury in some players was beyond the investigators control. Six players also reported injuries in both seasons however, only one of these was to the same body part (the knee) and was due to surgery to remove a screw from the previous year. Conversely, the intervention did appear to have provided a positive impact on reducing the severity and rate of knee injuries in particular. This is an important aspect to consider as knee injuries such as anterior cruciate ligament (ACL) injuries are common in soccer and can often be potentially season or career ending (Walden, et al., 2012). Previous literature has indicated that the FIFA 11+ S&C program is effective in decreasing ACL injuries and thus, the program is desirable by coaches and players as has proven to work (Walden, et al., 2012). Within the current study, the rate of both hamstring and knee injuries were decreased following the intervention mirroring similar results found in a study by Silvers et al. (2014) who reported significant reductions in ACL and hamstring injuries in NCAA soccer players.

The intervention did appear to reduce the rate of lower extremity injuries both per 1000 training and match hours. Most importantly, as it has been stated that majority of injuries often occur during matches, it was expected that injuries per 1000 match hours would decrease following the intervention. In this case, the intervention did prove to be successful as there was a decrease of 16% in injuries per 1000 match hours. This is important as a decrease in the days lost due to injury (whether it be in the lower extremity or the whole body) is desirable to allow for players to have as much opportunity to train and play as possible. Although there was an increase in injuries per 1000 training hours, it was very minimal at only 0.72. Grooms et al. (2013) also reported more injuries per 1000 match hours than per training hours thus supporting the results from the current study to be concluding similar outcomes.

Interestingly, there was an increase in the number of contact injuries in both the whole body and lower extremities during the 2014 season. This may have been a reflection of the improvement in the performance of the team within games. For example, it could be suggested that as they won more games in 2014, they may have performed harder challenges and tackles within matches and thus, been more susceptible to contact injuries. In contrast, although previous literature has suggested that the FIFA 11+ S&C program assists in preventing non-contact injuries, the current investigation reported no changes in these injuries (Grooms, et al., 2013). As the total number of injuries in the intervention season increased from 2013, it was not expected that the number of non-contact injuries would decrease. Ideally, the team would have undertaken conditioning training both during the pre-season and the competitive season. However, in the current study, the investigator did not have access to the team prior to the competitive season, as the final squad had not been decided until a week before games commenced (eg March). Had the program been implemented from earlier in the season (ie. pre-season), a more promising result may have occurred.

Furthermore, the type of injuries that occurred in the 2014 season did not differ substantially from the 2013 season with both muscle and bruise injuries increasing slightly. However, there was a decrease in the number of ligament injuries during the intervention season suggesting that the FIFA 11+ S&C program may be successful in preventing these type of injuries around joints such as the ankle and knee. Again, as the program aims to strengthen these joints, it is a main aim of the FIFA 11+ S&C to prevent injuries at these locations.

A number of factors exist that may play a role in the level of success the FIFA 11+ S&C program has in preventing injuries in soccer players. It has previously been mentioned that a major factor that can influence the success of the FIFA 11+ S&C is the level of compliance from the players (Steffan, et al., 2013; Steffan, et al., 2008). In particular, compliance has been suggested to be highly related to the level of effectiveness an injury prevention program may have on reducing lower extremity injuries (Sugiomoto, et al., 2012). Within the current investigation, the team had the investigator present at every training session to implement the program and thus, the level of compliance was given the best chance to be at an optimum.

The frequency at which the players complete the program can also be a key influencing factor as it has been stated that too low of a frequency (such as only once a week) is not efficient to illicit a physical response in regards to injury prevention (Al Attar, 2015; Hammes, 2015). A systematic review by Barengo (2014) concurred by concluding that players who had higher compliance and completed the FIFA 11+ S&C program at least

1.5 times per week reduced injury risk by 35%. Grooms et al. (2013) also stated that performing the FIFA 11+ S&C program five to six times per week can potentially reduce injuries to the lower extremity by 82%.

One level of compliance that can be taken is the attendance rates of the team. For example, if players do attend training, they are given the opportunity to complete the FIFA 11+ S&C program whilst there and avoid missing the conditioning component of the session. In the current study, there was an increase in attendance rates between the 2013 and 2014 seasons with the latter presenting a higher level of attendance of 88.9% compared to 80.1%. Thus, it can be suggested that the compliance rates during the intervention season were good so potentially, compliance levels did not hinder the effect of the FIFA 11+ S&C program.

The timing of implementation of the FIFA 11+ S&C program within a training session can also be a vital indicator of whether it will be successful. The program was designed to be implemented as a warm-up before a training session as used within the current studies method. The rationale for this timing technique is that the program can be utilised as a dynamic warm up as well as the fact that it allows for a potentially better level of compliance from players as they are generally in a less fatigued state before beginning the session (Al Attar, 2015). This technique of timing proved to be successful within the current amateur team as it was found that all players who attended sessions generally performed the program at the start of the session unless they were injured. Thus, the level of compliance was as high as possible within the current investigation.

As the FIFA 11+ S&C program was only implemented throughout the competitive season, it is suggested that more significant improvements may have occurred if it was introduced during the preseason period. For example, Grooms et al, (2013) concluded that the promising improvements that occurred in their particular study were due to the intervention period going from pre-season and then throughout the season. Thus, physiological performance increases that were encouraged by the FIFA 11+ S&C program were less likely to deteriorate (Padua, et al,, 2012).

Regardless of the compliance rates the FIFA 11+ S&C program is considered to be both cost effective and easy to follow due to minimal equipment required. There is also in depth explanation of the exercises involved and it is considered to be easy to implement in players at lower levels of competition (Barengo, et al., 2014). Consequently, the program is considered to be viable option for coaches of amateur teams who want to aid in injury prevention during the session where possible.

Overall, common limitations that many injury prevention studies have demonstrated are continued follow-up, lack of compliance and necessary progressions (Grooms, et al., 2013; Steffan, et al., 2008; Sugimoto, et al., 2012). In the current study, these limitations were addressed appropriately by allowing for weekly consultation with the investigator, weekly implementation of the FIFA 11+ S&C program and suitable progressions as required throughout the season. However, there were some additional limitations that were beyond the investigators control. Only one team was used during each season which limited the number of total players. Unfortunately, due to only one team being available at this sub-elite level within the region, this could not be changed. This also meant that the playing squad changed slightly from 2013 to 2014 even though the same team and club were used from year to year. Finally, the investigator could not implement the use of Global Positioning System (GPS) data in both years due to the decision by the coaches. This limits the analyses of training loads (TL) and it is suggested that future studies include this if possible to investigate the training structure component of this study more intently.

Finally, the intervention team also appeared to perform better at a league competition level during 2014 as not only did they increase their win rate from 18% of games to 58%, but they also finished second on the ladder (as opposed to tenth the previous season). Additionally, there was an improvement in for and against from -38 to +16 goals in the intervention season. Whilst this is purely speculative and not necessarily a mechanism, these improvements in overall team league performance might be able to be attributed to the decreases in time lost due to injuries because the players were able to train and play at an improved rate, and were given more opportunities to train and maintain fitness and skills. Thus, players could perform at a more optimal level during games as they had trained at a similar level during training.

6.5 Conclusions

In conclusion, it is suggested that the FIFA 11+ S&C program may be more effective than the often-used traditional warm up in preventing injuries (particularly to the lower extremity).

As demonstrated within the current study, the FIFA 11+ S&C program is effective in reducing the severity of lower limb injuries in amateur players. The conditioning protocols utilised have also proven to be successful in decreasing the time lost due to injuries, thus allowing for players to return to sport sooner following injury.

The program may be effective in sub-elite and amateur soccer teams where there are time and financial constraints, which may limit fitness progressions during a season. Coaches should focus on ensuring the program is implemented a sufficient number of times per week (at least twice is suggested) in order to target injury prevention. The program may also be successful in limiting the time lost from sport due to injuries and thus, potentially aiding in team performance.

However, although the results from the current study indicate success with an intervention program such as FIFA 11+ S&C, the present population group consisted of amateur male players. Thus, it is recommended that further research be undertaken to investigate the use of such a program within other soccer teams and age groups.

7: The effects of SSG on the seasonal fitness of sub-elite Australian soccer players

Chapter 6 demonstrated that the use of a soccer specific S&C program was successful in decreasing in the severity of injuries and the number of days lost to injuries during a competitive season. However, although Chapter 6 did not discuss whether the S&C program influences positive improvements in seasonal fitness, the teams did perform regular fitness testing throughout the season to demonstrate the effect of their respective training designs on seasonal fitness. Thus, the aim of Chapter 7 is to compare the seasonal variations in fitness of sub-elite male soccer players training both with and without a soccer specific conditioning program including use of the FIFA 11+ program.

7.1 Introduction

Success within the game of soccer requires players to acquire and maintain an adequate level of physiological fitness throughout a season (Caldwell & Peters, 2009). In order to achieve this fitness, players must be able to perform sport specific activities both during training and in games including short sprints, kicking, tackling, jumping, turning and controlling the ball (Magal, Smith, Dyer & Hoffman, 2009). To be successful within a game, players must have the capacity to perform these movements utilising flexibility, agility, speed, anaerobic power and aerobic fitness (Caldwell & Peters, 2009; Magal, Smith, Dyer & Hoffman, 2009). Although physical capacity has been shown to generally improve during the pre-season, fitness can often fluctuate within the competitive season (Mohr & Krustrup, 2016). Therefore, it is important to frequently test players for soccer specific variables throughout the season to see where exactly these fluctuations occur and if the training programming is adequate in allowing players to improve their fitness (Kalapotharakos, Ziogas & Tomakidis, 2011; Silva et al, 2011).

Although there are various physical variables players must possess to be successful in soccer, the way in which these components are trained and maintained vary between individuals, teams and competitive levels (Arziz, Tan & The, 2005; Kalapotharakos, Ziogas & Tomakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Silvestre et al., 2006). Similar to the way that soccer specific training is necessary to get players match ready, periodized S&C is required to ensure players also meet the fitness demands of the sport (Gamble, 2006). In recent times, European countries such as England and

Switzerland have developed a new training technique that focuses on the use of small-sided games (SSG) to concurrently train fitness as well as tactical and technical skills (Aguiar, Botelho, Goncalves & Sampaio, 2013; Dellal, et al., 2008; Hill-Haas, Coutts, Dawson & Roswell, 2010).

The SSG approach to training has been popular with coaches as a number of physiological, technical and perceptual responses can be altered simultaneously by simply modifying game constraints such as the size of the pitch, number of players, coach encouragement or the rules (Castellano & Casamichana, 2010; Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Roswell, 2010; Mallo & Navarro, 2008). Although this approach to training has been proven to work with elite players in European countries, Australian teams are now trying to adopt the same strategy with sub-elite athletes (Castellano & Casamichana, 2010; Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Roswell, 2010; Mallo & Navarro, 2008). However, this approach is questionable for sub-elite teams due to the time and financial constraints and the lack of accessibility to S&C personnel that players often face at the Australian sub-elite level (Grove, Lavallee & Gordon, 1997). Consequently, sub-elite teams often end up relying solely on SSG for training fitness. However, this heavy reliance on SSG can be problematic as sub-elite players have decreased levels of physical, psychological, tactical and technical capabilities when compared to their elite counterparts and thus may not respond as positively (Owen, Forsyth, Wong, Dellal, Connelly & Chamari, 2015). It could then be suggested that sub-elite teams who attempt to use SSG to train fitness may not have the same positive results as their elite counterparts due to the many differences that exist between the two levels of professionalism.

Although seasonal changes in fitness and the use of SSG training has been investigated in soccer players individually at both the elite and sub-elite levels, few studies have explored the use of SSG training in a sub-elite Australian team. Thus, the purpose of this investigation was to determine if using SSG as the only form of training can increase fitness in sub-elite Australian soccer players. The second purpose of this study was to determine if using a combination of sport specific conditioning and SSG training can improve fitness in sub-elite Australian soccer players.

7.2 Methods

7.2.1 Experimental Approach to the Problem

The study was conducted on a regional men's soccer team that participated in an Australian winter season during March until September in 2013 and 2014. All players had been selected during trials at the beginning of the 2013 and 2014 season and were deemed to be of a sub-elite level. Although the squad changed from 2013 to 2014, the core group of the players remained the same. The years consisted of pre-competition (January to March) and competitive season (March-September) periods and fitness testing occurred at both pre- (March) and post- (September) season. Additionally, players were required to travel throughout the state for games as the team participated within a State League competition.

Anthropometric measures of height, body mass and body fat percentage were recorded immediately prior to the start of the first test session. The test sessions consisted of both generic and soccer specific tests with the first session focusing on upper and lower body flexibility and power, agility and speed with and without the ball and a multistage fitness test (MSFT). Following a 48-hour recovery period, the players completed the second session, which involved a Level 1 Yo-Yo intermittent recovery test (YYIR1). In order to control the study for variations in circardian rhythm and reporting purposes, all testing sessions were held in the early evening and the players first performed a standardised warm-up consisting of soccer specific exercises including leg swings, dynamic hip rotations and jogging progressing into sprinting. Flexibility, power, agility and speed tests were then completed three times with the best results recorded.

Additional training data were also recorded throughout the course of the season during training sessions such as training session structure (ie. total time allocated to the specific training components of conditioning, tactical and skills) and training and game attendance. Player attendance and training component data were recorded by the coach in order for the principal investigator to collect each week.

7.2.2 Subjects

Eleven (age 22.82±4.40, height 1.75±0.03m and weight 72.14±6.60kg) and 16 (age 22.25±4.11, height 1.80±0.06m and weight 77.39±7.67kg) male amateur soccer players from a regional Australian team participated in the study in 2013 and 2014 respectively. Prior to participating in the study players were explained in detail the circumstances under which the investigation would take place and both the risks and benefits of completing the study. Each player completed a medical history form and gave written informed consent. Players were asked to refrain from consuming any alcohol or caffeinated products in the 24-hour period leading up to testing sessions. The study was approved by the James Cook University Human Ethics Committee.

7.2.3 Procedures

7.2.3.1 Anthropometric Measures

Height was obtained to the nearest centimetre using a stadiometer while body mass and body fat percentage were measured utilising electronic digital scales (Tanita, Kewdale, Australia).

7.2.3.2 Flexibility and Power Development

A S&R test was used to measure trunk/ hamstring joint flexibility (Wells & Dillon, 1952).

Lower body power was assessed via the utilisation of a Yard Stick (Swift Performance, Lismore, Australia) VJ device. Starting height was first measured before the player was asked to perform a countermovement VJ at maximal capacity. Final jump height was measured to the nearest centimetre.

Previously, a backward overhead medicine ball throw has been used to determine upper body power production in NCAA college football players (Mayhew et al., 2005). In the current study this test was altered to be soccer specific by having a 3kg medicine ball thrown from behind the head, replicating a throw in. Players were asked to perform a standard soccer throw in with feet standing together. In order to perform an adequate trial, the throw had to adhere to the following specific criteria: the ball being released from behind the head, no movement of the feet and no arching of the back. A measuring tape was used to determine the distance the ball travelled to the nearest centimetre.

7.2.3.3 Agility and Speed

Electronic timing gates (Swift Performance, Lismore, Australia) were used to measure performance in both the 505 Agility test and 40 metre sprint tests. The 505 Agility test has been known to be a successful indicator of fitness and skill performance in soccer players and was therefore performed in the current study (Hoare & Warr, 2000). For completion of the test, players were instructed to accelerate at maximal speed through a set of timing gates set at a 10 metre mark, continue another 5 metres through to a set of cones before using their dominant foot to turn and run 5 metres back through the gates. Following completion of the trial, time was recorded via the gates to the nearest 0.01 seconds. Players completed three trials of the 505 Agility test both with and without the ball. When using the ball, players were instructed to use the outside of their dominant foot to turn and keep the ball as close as possible to the body to allow for the quickest time.

A 40-metre straight course sprint was used to assess for speed performance. Players were asked to stand with one foot on the starting line and to run at maximal speed through timing gates set up at 40 metres with sprint time being recorded to the nearest 0.01 seconds. Players performed three trials without the ball before completing an additional three trials with the ball to mimic match performance. Players had a five-minute rest between each trial (Sayers, Sayers & Binkley, 2008; Williams, Oliver & Faulkner, 2011). Players were instructed to keep the ball as close to the body as possible and to dribble it through the gates at maximum pace.

7.2.3.4 Aerobic Capacity

As it has previously been determined that soccer players require a good level of aerobic capacity, the YYIR1 was used to assess players for the ability to perform intense intermittent exercise (Sayers, Sayers & Binkley, 2008). Due to all players in the current study being deemed as being at an amateur level, it was appropriate that the Level 1 test was utilised. Additionally, all players performed a MSFT for a generic estimate of VO_{2max} (Ramabottom, Brewer & Williams, 1988).

7.2.4 Training Session Structure

Training session organisation was evaluated through the collection of data describing the type of training being undertaken in each individual session. Each session was divided into the sub-categories of 1) Conditioning 2) Tactical and 3) Skills. Conditioning was divided into conditioning both with and without the ball. Conditioning with the ball was deemed to be any fitness training including the use of agility poles with and without the ball and sprints (Foran, 2011). A session that incorporated any focus on the ball such as shooting or dribbling practice was deemed to be skills training while tactical training was considered to be any time that was allocated to team or player strategy practice such as formation practice. SSG training was considered to be anything within these three sub categories that resembled game training or run-throughs. The coach was asked to provide a time allocation for each of the above components via the provided data sheets and these were collected by the principal investigator on a weekly basis.

7.2.5 Intervention

The pre-season period lasted for eight weeks in both the 2013 and 2014 seasons with the competitive seasons lasting 21 weeks and 26 weeks respectively. The intervention implemented during the 2014 season consisted of periodised soccer specific conditioning training that had previously been proven to work with various other soccer teams. As recent research has shown that the amount of time spent at 100% or more of Maximal Aerobic Speed (MAS) is considered to be a critical factor in improving aerobic power, differing methods of MAS training were implemented particularly during the pre-season period in an attempt to train aerobic capacity (Baker, 2011). Each player was assessed in a 1500 metre time trial at the beginning of the pre-season to determine which of the six applicable fitness groups they would be allocated to (with Group 1 consisting of those who performed the time trial the fastest and Group 6 having the slowest). Each group would then perform the same weekly training sessions but individual groups would work in accordance to their respective level of fitness (eg. Group 1 would generally perform farther distances than Group 2 whilst working for the same amount of time and so on). The sessions each week varied and included methods of maximal grid running, Tabata style training, the Eurofit method and Modified Tabata training with intensity building throughout the pre-season period as the players's fitness progressed (Baker, 2011).

In regards to strength and proprioception training, the FIFA 11+ program was utilised as it has been deemed an appropriate method of training lower body and core strength as well as preventing injuries (Silvers-Granelli, et al., 2015; Barengo, et al., 2014; Al Attar, et al., 2015). The 20 minute program is performed on-field, does not require any equipment and involves 15 exercises which are divided into three components; 1) running with change of direction 2) strength, plyometric and balance 3) running with warm down. Each exercise has three varying degrees of difficulty that are increased according to individual and team progression (Silvers-Granelli, et al., 2015; Barengo, et al., 2014; Al Attar et al., 2015). For the current study, the MAS training was performed twice weekly during the preseason period and then once weekly during the competitive season. The FIFA 11+ program was performed one to two times per week for the duration of the competitive season. The specific conditioning session's outlines ran for approximately 15-20 minutes twice per week.

7.2.6 Game Outcomes

The outcomes from each game were recorded as either a win, loss or draw. Additionally, total goal difference was calculated at the end of the season. All game outcomes and goal differences were taken from regular competitive season games excluding any games in pre-season or during the finals series at the end of the season.

7.2.7 Statistical Analyses

Fitness Data

Results are presented as mean ± standard deviation and paired t-tests were used to determine differences between pre- and post-season data. No analysis was conducted on mid-season results due to an insufficient number of players completing the testing sessions. Analysis was not conducted between seasons due to the variation in players involved in the 2013 and 2014 seasons. Statistical significance was set at an alpha 0.05 and all data was analysed using SPSS Version 20.

7.3 Results

There were no significant changes in any of the fitness variables tested throughout the 2013 season. Similarly, the 2014 team had no significant changes in any fitness tests except significantly increasing body fat percentage at post-season testing. Both teams presented a plateau in fitness performance in majority of the variables including flexibility, power, agility, speed and aerobic capacity from pre- to post-season. The YYIR1 test was not completed in 2013 due to the players not being available at last minutes notice due to the coach's discretion. Additionally, the agility test both with and without the ball and the MSFT were not completed in 2014 due to rain and the unavailability of an appropriate replacement surface. Thus, the tests not completed were not included for analysis.

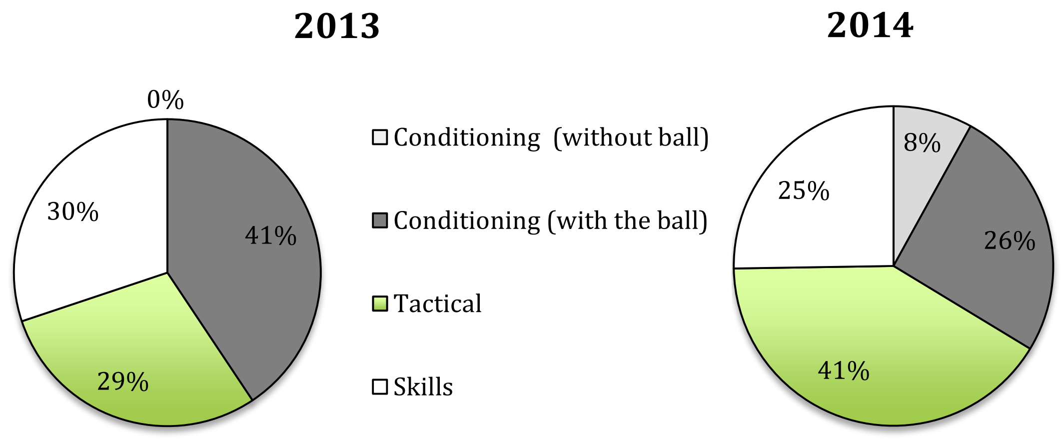
Table 7.1 2013 vs. 2014 season's fitness data

Test	2013		2014	
	Pre	Post	Pre	Post
Height (m)	1.75±0.03	1.75±0.03	1.80±0.06	1.81±0.06
Weight (kg)	71.54±6.82	71.99±6.60	77.39±9.67	76.7±9.41
Body Fat (%)	13.76±2.85	14.45±2.01	11.84±4.70	14.79±3.34*
S&R (cm)	13.70±6.94	14.5±7.82	12.71±8.27	11.67±7.76
VJ (cm)	64.8±7.98	57.00±8.86	57.25±8.02	55.08±8.05
OHT (m)	9.00±0.84	8.30±0.89	8.30±1.18	7.90±1.35
505 Agility (s)	2.17±0.05	2.16±0.03	Did not complete	
505 Agility with Ball (s)	2.73±0.11	2.80±0.13		
40m Sprint (s)	5.51±0.17	5.52±0.06	5.50±0.23	5.38±0.33
40m Sprint with Ball (s)	6.33±0.45	6.17±0.27	6.14±0.25	6.53±0.57
VO_{2max}	54.90±6.42	53.50±5.41	67.06±6.26	66.30±7.23

* indicates significant improvement from preseason testing

Figure 7.1 shows a comparison between the training session designs of the observational (2013) and intervention (2014) seasons. The investigator implemented conditioning without the ball component in the intervention season to ensure specific soccer fitness was trained in some form every week. The time allowed by the coach for this to happen was fairly minimal but nonetheless, it was more than during the observational season.

Figure 7.1 *A comparison of training component design between 2014 and 2013*



The 2014 season produced better results in terms of games won, as there was an improvement from four wins to fifteen wins during the intervention season (Table 7.2). Additionally, it was also found that there was an improvement in the goal difference score at the end of the season with an increase from (-38) to (+16) goals.

Table 7.2 Comparison of Game Outcomes During the 2013 and 2014 Seasons

	2013	**2014**
Goals For	30	64
Goals Against	68	48
Total:	(-38)	(+16)
Wins	4	15
Draws	1	3
Losses	17	8
Total Games:	22	26
Final Ladder Place:	10	2

**Please note: figures are only for games prior to post season testing and excluding finals game*

7.4 Discussion

The first aim of this investigation was to determine if using SSG as the only form of training could increase fitness in sub-elite Australian soccer players. The second purpose of this study was to determine if using a combination of sport specific conditioning and SSG training could improve fitness in sub-elite Australian soccer players.

From pre-season testing to post-season testing it was found that there were no significant changes in fitness throughout the 2013 season in the sub-elite team. Following the intervention in the 2014 season, there were no significant changes in fitness with only a significant reduction in body fat percentage.

It was seen that within both the 2013 and 2014 seasons, the overall training session design implemented by the coach had a major focus on SSG. However, what was lacking was that the SSG in both seasons had no progression in terms of periodization of training variables including intensity, frequency and duration. The conditioning that was executed in the 2014 season by the investigator was controlled and periodized to ensure duration and intensity was appropriately designed for the applicable training load each week according to the level of competition and playing schedule. However, as the conditioning component made up such little of the total training time, it can be suggested that the overall training design in both seasons could have been improved on by allocating a greater percentage of time to non-ball specific training.

In addition to the aforementioned explanations for a lack in change of fitness during a season, there are also multiple reasons as to why players may not improve individual variables. For example, although flexibility did not improve during the season in the current sub-elite team, Caldwell & Peters (2009) found an improvement in a sub-elite English conference team of a similar age and competition level. This significant increase in flexibility was stated to possibly have occurred due to the "moderate" and "high" levels of flexibility training sporadically throughout the season (Caldwell & Peters, 2009). In comparison, the Australian team did no specific flexibility training nor had any focus on stretching during the 2013 season and may have showed no significant improvements due to this reason. Flexibility and mobility were focused on more during the 2014 season however, they were still only trained every few weeks during the 20 minutes allocated for specific conditioning training due to time constraints. Thus, this minimal training wasn't expected to have much influence on improving flexibility during the season.

It has been suggested that improvements and maintenance of VJ performance is often due to a training effect allowing for greater coordination of these muscle groups resulting in more effective and powerful jumps (Clark, Edwards, Morton & Butterly, 2008). Additionally, Caldwell and Peters (2009) stated that increases in lower body power performance can be enhanced with basic, functional muscle strength training such as weight and plyometric training. It may be possible that the reason as to why the 2013 sub-elite team did not have any improvements in lower body power is due to the lack of specific strength training done throughout the season. Although the 2014 team did include some form of specific strength training, it was merely based on body weight movements as players had stated they had performed minimal strength training previously and were thus classed as novices. Additionally, as it was a sub-elite team, accessibility to a gym and weights was an issue and therefore, all strength training had to be implemented on the field so using body weight exercises was appropriate. It could be suggested that this body weight training was not enough to induce a strength response that was high enough to carry through to improving VJ performance.

Sprint performance is commonly tested in soccer players and it is deemed to be of great importance in the game due to players having to perform them at high speed and with great recovery (Wong, Hejelde, Cheng & Ngo, 2015). It has previously been reported that sub-elite teams who implemented appropriately supervised S&C training had improvements in sprint performance during the season despite only having two training sessions in total a week (Caldwell & Peters, 2009; Magal, Smith, Dyer & Hoffman, 2009). Again, this demonstrates the importance of including appropriate soccer specific conditioning training into sessions in sub-elite teams. Although there was specific conditioning training incorporated in the 2014 pre-season, the sessions may not have included enough speed training to improve sprint performance.

Aerobic capacity is considered to be one of the main physical components of fitness that needs to be focused on during the soccer season for a number of reasons. It is considered to play an integral role in high performance soccer as it has been shown to reflect where teams may rank in the league and additionally, can assist in program design and implementation of training sessions throughout a season (Kalapothrakos, Ziogas & Tomakidis, 2011). Both the observational and intervention seasons reported no change in aerobic performance following post-season testing. Similarly, studies by Casajus (2001), Silvestre et al. (2006) and Cardwell and Peters (2009) all concluded that there was no change in aerobic performance during their respective seasons. It has been suggested that an increase in aerobic performance at the end of the season may be due to players starting the season with less than optimal aerobic capacity levels which are then able to be improved upon throughout the competitive season (Casajus, 2001; Magal, Smith, Dyer & Hoffman, 2009; Silva, et al., 2011). Additionally, it is commonly thought that in order to improve aerobic performance, aerobic training needs to be the main focus of sessions. However, it has been concluded that both anaerobic and aerobic focused sessions can enhance aerobic performance as Dupont, Akakpo and Berthoin (2004) demonstrated by improving an elite European team's performance through the use of MAS training. Nonetheless, the intervention team had a high use of SSG training combined with specific conditioning training yet did not report improvements. Therefore, it could be suggested that the conditioning component of training may not have been sufficient to induce aerobic conditioning appropriately.

There are a number of reasons as to why teams including the current sub-elite teams, often report no significant improvements in numerous fitness variables following the completion of a competitive season. When determining potential reasons as to why, it is important to consider the overall physical state and level of the players both before and during the competitive season. The first reason could be that over the pre-season the athletes do their conditioning and then peak at the end of pre-season. Following this training, they begin their competitive season at peak condition and then remain at this level for the duration of the season. Evidence of this has been shown in Casajus (2001) where players were reported to have reached their peak aerobic capacity at the beginning of the competitive season and thus found it difficult to improve upon this as the season progressed. A second reason could be that players at the sub-elite level often become deconditioned in the off-season due to a cessation in training during the break between competitive seasons. Thus, players at this lower level of soccer may return to preseason training only to be put under immense pressure to increase their fitness in order to reach the high level needed to perform. Consequently, the players may end up with physical and mental fatigue during later stages of the season due to the need to improve in such a short amount of time (Caldwell & Peters, 2009). Furthermore, these high levels of stress and fatigue due to too high of a stimulus can often result in acute overtraining syndrome which can then be further deteriorated in the competitive season (Kraemer, et al., 2004). When combined, deconditioning and fatigue could play a role in preventing improvements in fitness throughout the season and these factors must be avoided where possible in order for players to be able to perform optimally. It is therefore important for coaches to consider the foundation fitness level their players have at the start of the season and adjust their training program accordingly to ensure overtraining does not occur.

The lack of improvement in fitness performance in the current teams could also be attributed to the style of training that was implemented during the seasons. For example, the 2013 sub-elite team solely relied on SSG for conditioning training throughout the season and did not include any specific conditioning training in either the pre- or competitive season despite only training two to three times a week. Although the 2014 team attempted to incorporate some soccer specific conditioning throughout the season, there was still only a small amount of time allocated to conditioning without the ball due to the coach's preferences. Therefore, the time spent on conditioning specifically for fitness was minimal and may not have been long enough to induce a physiological change. Likewise, a sub-elite NCAA team in the study by Magal, Smith, Dyer and Hoffman (2011) reported minimal improvements in performance post-season and they too followed a training program that mainly consisted of SSG twice a week with minimal unassisted S&C training.

In an attempt to seemingly train like the elite teams, sub-elite teams including the current Australian team in this study, often heavily rely on the use of SSG throughout the season to not only improve tactics and skills, but also to improve conditioning. This is often due to the time and financial constraints of more amateur teams and the need to 'train everything at once'. However, it is evident that this technique of training may not be suitable to those teams below the elite level as the current sub-elite teams who followed this training method, did not experience any real significant improvements in fitness performance during the season. A lower level of skill ability and a lack of accessibility to professional S&C personnel, provide further reasoning as to why training like the elite may not necessarily work with sub-elite teams. Additionally, the fact that teams at all levels who included further conditioning training in their season, often improve in at least one or two fitness variables at post-season, adds further support as to why training must be individualised based on time constraints (Arziz, Tan

& The, 2005; Kalapotharakos, Ziogas & Tomakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Silvestre et al., 2006).

Finally, the intervention team also appeared to perform better at a league competition level during 2014 as not only did they increase their win rate from 18% of games to 58%, but they also finished second on the ladder (as opposed to tenth the previous season). Additionally, there was an improvement in "for and against" from -38 to +16 goals in the intervention season. Unpublished data collected on injuries suggests that these improvements in overall team league performance could be attributed to the decreases in time lost due to injuries because the players were able to train and play at an improved rate as they were given more opportunities to train and maintain fitness and skills. Thus, players could perform at a more optimal level during games as they had trained at a similar level during training. Furthermore, a change in coaching personnel and coaching tactics between seasons may have played a role in the improvement of game and goal outcomes during the 2014 season.

In conclusion, although the sub-elite team attempted to adapt the same style of SSG training as elite teams both with and without additional fitness conditioning, there were no improvements in fitness in either season. These absences in improvement were suggested to be due to the low abilities of the sub-elite team to perform SSG to an adequate intensity to be effective. However, given that there was an absence of GPS data to ascertain speed and distance, further research is required as this point is purely speculative. Additionally, the issues that may influence implementing the program appropriately such as time and financial restraints may have also produced the plateaus in physical performance.

7.5 Practical Applications

It is suggested that in order for players to have the best chance at both improving fitness and performing well in games during the season, it is important for coaches of sub-elite teams to consider the team's skill level when designing and implementing training sessions. Whilst there is no cause and effect relationship and other factors may also influence the outcome throughout the season such as coaching tactics and player changes, it is suggested that coaches consider allocating more time to non-ball specific training. It is recommended that in addition to SSG training, there is specific conditioning time without the ball included throughout both pre-season and competitive season training, to prepare players for both weekly competition games and finals preparation.

It is especially important for the coaches of sub-elite teams to consider the abilities and opportunities of their players to avoid missing out on the essential conditioning that can come when training with SSG. In order to assist in training fitness and avoid under-conditioning during the season in sub-elite teams, it is suggested that an off-season fitness maintenance program also be implemented with a significant focus on S&C elements to target those physiological variables utilised in soccer and prepare players for the season to come.

8: Impact of soccer specific program on fitness and injuries in amateur players: case study

Chapter 7 demonstrated that although in-season training with the soccer specific S&C program improved game results, it was found to be insufficient for improving seasonal fitness. As such, it was decided that pre-season training would be included in the following season as well. As Chapter 7 also presented issues with the investigation in terms of coach and player compliance and education, it was decided that the investigation would continue to be conducted on a amateur soccer team within the Far North Queensland region. This change in clubs allowed for more investigator access to the team in terms of both individual session time and the ability to begin research during the pre-season period starting in January. Additionally, Chapter 8 incorporates the implementation of a S&C intervention in the pre-season period as well as through the competitive season. Thus, the aim of this chapter is to provide a case study focusing on the implementation of a S&C intervention during both the pre- and competitive season in amateur Australian soccer players and determine if such a program is successful in improving seasonal fitness and reducing injury rates.

8.1 Introduction

Soccer is defined as an intermittent sport and requires numerous physiological components in order to be successful (Ramirez-Campillo, et al., 2014). Throughout the 90-minute game, varied powerful movements are necessary and are often associated with a high aerobic capacity. Additionally, actions such as kicking, jumping, sprinting, changing direction and throwing also occur frequently (Köklu, Aşçi, Koçak, Alemdaroğlu & Dündar, 2014; Ramirez-Campillo, et al., 2014; Schmikli, et al., 2011; Stolen, 2005). Many of these movements entail the player to have good abilities in strength, power, agility and speed, which then work in conjunction with aerobic capacity to create an adequate overall physical ability for soccer (Caldwell & Peters, 2009; Magal, Smith, Dyer & Hoffman, 2009).

In addition to the physical aspects that are required within soccer, players also need to attain and maintain technical and tactical capacities (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011). Consequently, in modern day soccer, coaches often use the technique of small-sided games (SSG) training in an attempt to target all areas of game preparation at once (Casamichana, Castellano & Castagna, 2012; Little & Williams, 2006). This method has been shown to be particularly popular, as it is known to be effective irrespective of level of play or age (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011). In particular, using SSG during the week has become common practice in professional and semi-professional teams in an attempt to promote team and individual fitness whilst acquiring and maintaining skill development (Casamichana, Castellano & Castagna, 2012). Although SSG have proved to be successful in training game-like situation fitness including the ability to have good aerobic capacity and agility, this method of training is only advocated once players have a high level of technical skill (Turner & Stewart, 2014). As previous literature has shown that differences exist between the way in which amateur and elite players perform SSG including their capacity to perform high-intensity movements such as sprints, it can be questioned as to whether SSG alone is the most appropriate method for amateur players (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011). Furthermore, there are differences between professionalism levels in their execution of technical actions including loss of ball possession and the completion of successful passes so it could be suggested that amateur players may not be able to complete SSG at a high enough intensity to simulate game responses (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011). Thus, it could be suggested that players may experience greater improvements in fitness with a program that integrates both SSG and specific soccer conditioning exercises.

With soccer injuries being among the highest of all sports, particularly in adult amateur men, they can also play a key role in influencing the fitness of soccer players throughout a season (Schmikli, et al, 2011). The longer a player is injured, the more training sessions, games and fitness opportunities they are likely to miss so injury prevention is often highly desired by players at all levels of professionalism. However, as lower level teams often don’t have the financial and professional service capacities of more elite teams, accessing medical support once a player is injured can be hard if at all possible. Therefore, injury prevention is often highly desired at this level. In recent years, the FIFA 11+ program has proven successful in decreasing injuries in soccer players however the majority of the previous research has focused on European and Northern American teams at the semi-professional and elite levels (Owoeye, Akinbo, Tella & Olawale, 2014; Silvers-Granelli, et al., 2015; Steffan, et al., 2013). Additionally, SSG have been shown to prevent injuries more so than traditional training in rugby league players providing evidence that SSG may offer a safe and effective environment for conditioning training and injury prevention in team sports (Gabbett & Mulvey, 2008). More research is required to determine if the program is as effective in teams in other regions of the world such as Australia and in lower level amateur competitions.

Although there have been previous studies that have investigated the impact of SSG training and soccer specific S&C protocols including the FIFA 11+ program, they have mainly focused on European and American teams with no research conducted on Australian players (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011; Krist, van Beijsterveldt, Backx & de Wit, 2013). Additionally, majority of research focuses on two points of time (pre- and post-season measures) so it could be questioned as to whether information about changes in fitness throughout a season could be identified further with additional time points at the beginning of pre-season and at mid-season being investigated (Owoeye, Akinbo, Tella & Olawale, 2014; Silvers-Granelli, et al., 2015; Steffan, et al., 2013).

Therefore, the question exists as to whether SSG in conjunction with a specific conditioning program including the FIFA 11+ program may assist those less skilled players such as amateur players in improving fitness. The purpose of this investigation was to determine the impact of utilising a combination of SSG training and a soccer specific S&C program on the fitness, injuries and attendance of Australian amateur soccer players.

8.2 Methodology

8.2.1 Experimental Approach to the Problem

The investigation focused on a regional amateur men's soccer team in Australia during February until September in 2015. The players participated in the Far North Queensland regional competition with the pre-season existing from the start of February until end of March and the competitive season beginning in March and ending in September. Fitness testing was conducted at four points during the year in February, March, June and September (pre-pre, pre, mid and post respectively).

Anthropometric measures including height, body mass and body fat percentage were recorded prior to the start of each fitness testing session. Each testing session included general and soccer specific tests and occurred at the same time of day (early evening) to control for variations in circardian rhythm and reporting purposes. Three trials were completed for all flexibility, strength, power, agility and speed tests with the best trial result being recorded for analysis.

Additional training session data were recorded during the year including training session structure data (eg. The time allocated to the specific training components of conditioning, tactics and skills), game and training session attendance and incidences of player injury. The investigator collected all training data on a weekly basis.

8.2.2 Subjects

Eighteen male amateur soccer players (24.49±4.86 years; 1.79±0.05m; 77.0±11.99kg) from a regional team in Far North Queensland, Australia participated in the investigation. Prior to participating, the study was explained in detail to the players including the circumstances under which the investigation would take place and both the benefits and the risks of the completing the study. Each player completed a medical history and consent form and provided written informed consent to participate in the study. The study was approved by the James Cook University Human Ethics Committee.

8.2.3 Procedures

8.2.3.1 Anthropometric Measures

Height was measured using a stadiometer to determine the height of the player standing with flat feet to the nearest centimetre. Body mass and body fat percentage were measured with electronic digital scales with players standing with no shoes (Tanita, Kewdale, Australia).

8.2.3.2 Flexibility and Power Development

A S&R test was utilised to measure hamstring, trunk and joint flexibility (Wells & Dillon, 1952).

Lower body power was assessed using a Yard Stick VJ device (Swift Performance, Lismore, Australia). The players starting height was measured first before the player was asked to perform a maximal countermovement VJ. Final jump height was recorded to the nearest centimetre.

Upper body power was assessed via the use of an overhead medicine ball throw. Previously, Mayhew et al (2005) utilised a backward overhead medicine ball throw to determine upper body power production in NCAA football players. This method was altered within the current study to reflect an overhead soccer throw within a game by having a 3kg medicine ball thrown from behind the head. Players were instructed to perform a standard soccer OHT with feet together. To perform a successful throw, the ball had to be released from behind the head with no movement of the foot or arching of the back. The distance the ball travelled as measured to the nearest centimetre utilising a measuring tape.

8.2.3.3 Agility and Speed

Electronic timing gates were utilised to measure agility and speed performance in the 505 Agility test and 40-metre sprint test respectively (Swift Performance, Lismore, Australia). The 505 Agility test has previously been successful in indicating fitness and skill performance in soccer players and was thus used within the present study (Hoare and Warr, 2000). Players were instructed to accelerate at maximal speed through a set of timing gates set at the 10-metre mark. They were to continue another 5 metres through a set of cones and turn using their dominant foot to turn and run back through the timing gates at maximal speed. Time was recorded to the nearest 0.01 seconds and players completed three trials of the test both with and without the ball. During the trials with the ball, players were asked to use the outside of their dominant foot to turn and keep the ball as close to the body as possible to allow for the quickest time of test completion.

A 40-metre straight course sprint was used to assed speed performance. Players were instructed to stand with one foot on the starting line and to run at maximal speed through three sets of timing gates that were set at 10, 20 and 40 metres. Sprint time was recorded to the nearest 0.01 seconds. Players performed the sprint trials three times both with and without the ball to mimic game situations and it was instructed that when the ball was used, it was to be kept as close to the body as possible to allow for maximal pace (Sayers, Sayers and Binkley, 2008). A five-minute rest between each trial allowed for player recovery as previously utilised by Williams, Oliver and Faulkner (2011).

8.2.3.4 Aerobic Capacity

Players performed both a MSFT (MSFT) and a Yo-Yo Intermittent Recovery Test (YYIR1) to test for aerobic capacity in both a generic and soccer specific competences (Sayers, Sayers and Binkley, 2008). As the players were deemed to be at an amateur level, the Level 1 version of the YYIR1 test was utilised.

8.2.4 Training Session Structure

Training session structure was evaluated by collecting data describing the types of training that were used during each training session. Each session was divided into the designated training components of 1) Conditioning 2) Tactical and 3) Skills. Conditioning was further divided into conditioning both with and without the ball. Conditioning with the ball was deemed to be any training for fitness including sprints and the use of agility poles with and without the ball (Foran, 2011). Tactical training was considered to be any time that focused on team or player strategy such as formation practice whilst skill training was any training that focused on the ball such as dribbling or shooting practice. The investigator worked in conjunction with the coach to report time allocations for each training component via data sheets and these were collected on a weekly basis by the investigator.

8.2.5 Attendance

The primary investigator and coach collected attendance at weekly training sessions and also determined the reasoning behind players being absent at testing sessions including injury, sickness, or leaving town.

8.2.6 Injury Data

The investigator assisted individual players in completing an injury form if they were to succumb to an injury. An injury was defined as anything physical that prevented the player from performing a training session or game at 100% capacity, or any physical complain irrespective of time lost from physical activity or the medical attention given (Fuller et al, 2006). The injury form consisted of information on where and how the injury occurred, injury type and severity, the body site of the injury and the number of games and/or training sessions that were missed due to the injury (Gabbett, 2003).

8.2.7 Intervention

The soccer specific intervention also consisted of periodised conditioning training that focused on a number of different soccer specific fitness variables including aerobic capacity, agility, speed, strength, power and balance. The investigator implemented all conditioning training without a ball to ensure soccer specific fitness training was trained in some form every week. The first form of training was aerobic capacity training which consisted of Maximal Aerobic Speed (MAS) training and was completed twice weekly during the pre-season period and once weekly during the competitive season. The FIFA 11+ program was used to target the remaining fitness variables and was performed one to two times per week throughout the entirety of the pre- and competitive season.

Overall, each player completed two conditioning training sessions per week lasting 30 minutes each.

As part of the coach's requirements of conditioning training, SSG were incorporated into sessions on a weekly basis. Generally, 5-10 minutes per session was allocated to SSG training and this was often performed at the end of conditioning session. This allowed for the players to complete the specific conditioning without the ball whilst fresh and without fatigue.

As recent research indicates that the amount of time spent at or above 100% of MAS is a critical factor in improving aerobic power, a number of MAS training methods were implemented particularly during the pre-season period to train for aerobic capacity (Baker, 2011). Each player completed a 1500 metre time trial at the beginning of pre-season and then allocated to one of six fitness groups (with group 1 consisting of the fastest and group 6 consisting of the slowest to complete the time trial). The players then performed weekly training sessions that were similar style of training but appropriate to their individual fitness level in terms of speed. The session methods varied each week from maximal grid running, the Eurofit method, Modified Tabata and Tabata style of training with the intensity building through the pre- and competitive season as the players' fitness progressed (Baker, 2011).

The players also completed strength and proprioception training under the scope of the FIFA 11+ program as it has previously been deemed an appropriate program for traning core and lower body strength and as in injury prevention program (Al Attar, et al., 2015; Barengo, et al., 2014; Silvers-Granelli, et al., 2015). The program was performed on the field as it did not require any equipment and took only 20 minutes to complete. The FIFA 11+ program was implemented at each training session and consisted of 15 exercises with varying levels of difficulty based on the ability of the player. The exercises targeted the areas of change of direction in running, plyometrics, strength and balance and running (Al Attar et al., 2015; Barengo, et al., 2014; Silvers-Granelli, et al., 2015).

8.2.8 Statistical Analyses

8.2.8.1 Fitness Data

Results are presented as raw data for pre-pre, pre-, mid- and post-season fitness results.

8.2.8.2 Attendance

Attendance data are calculated as the number players who attended and those who were absent at each testing session. Additionally, absences were presented according to the reasoning for players missing sessions.

8.2.8.3 Training Components

Training components are presented individually as a percentage of total training time.

8.3 Results

8.3.1 Attendance and Compliance

During the course of the season, the number of players that attended and completed fitness testing varied and essentially decreased at each session as demonstrated in Figure 8.1. At Pre-Pre testing in January, there were 18 players that participated however, this number increased to 22 at Pre-season testing in April. At Mid-season testing in June this number then decreased to 15 and then again to 6 at Post-season testing in September. However, due to the ever changing squad during the season, the players who attended sessions were not always the same players. Therefore, as the players needed to have completed every testing session to be included in the final analysis, attendance numbers at each testing session were actually 18, 13, 5 and 2 at Pre-Pre, Pre-, Mid- and Post-season testing respectively as shown in Figure 8.2. Consequently, only two players completed all testing sessions and were included in the final fitness testing analysis.

Figure 8.1 Player attendance numbers at fitness testing sessions throughout the season

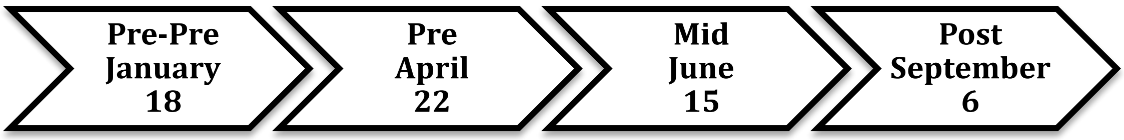
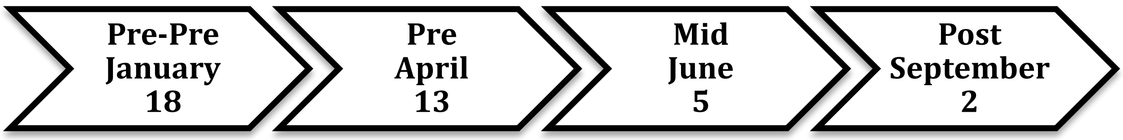


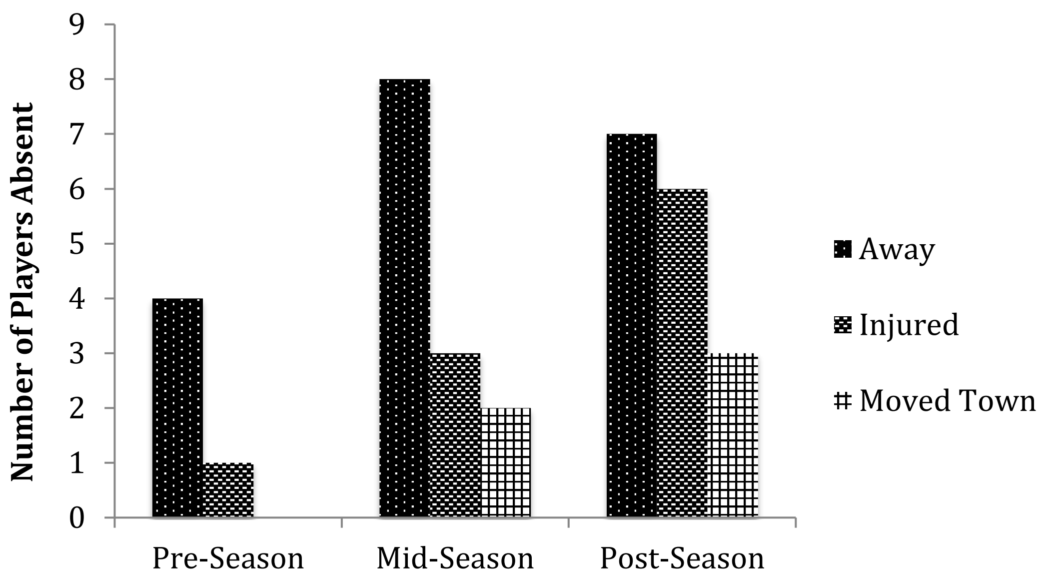
Figure 8.2 Number of players who had attended the previous testing session



8.3.2 Reasoning for Player Absence at Fitness Testing

There were a number of reasons that players were absent at fitness testing sessions throughout the season with players being away being the main contributor followed by injuries or moving town as shown in Figure 8.3.

Figure 8.3 Reasons for player absence at fitness testing sessions



8.3.3 Case study players attendance during the season

In regards to the two players who completed all four testing sessions during the season, it was found that Player A attended 100% of all training sessions while Player B attended 95% of training sessions.

8.3.4 Fitness Testing

The fitness testing results of only the two players who participated in all testing sessions were analysed in order for a full-season evaluation to be completed. There was shown to be an improvement in majority of fitness variables in both players from pre to post season testing. Aerobic capacity was reported to improve with both the YYIR1 and MSFT results increasing with each testing session as did the 40-metre sprint with the ball. Although all fitness variables improved from pre to post season except the overhead medicine ball throw and 7 stage abdominal test, there were also minor improvements and deteriorations seen between pre- and mid-season testing.

Table 8.1 Between player comparison of changes in fitness at Pre-Pre, Pre, Mid and Post season

	Player A				Player B			
	Pre-Pre	Pre	Mid	Post	Pre-Pre	Pre	Mid	Post
Height (cm)	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77
Weight (kg)	88.8	84.2	83.1	83.1	64.3	64.8	65.4	65.6
Body Fat %	25.6	17.5	16.2	9.2	3.8	4.1	4.9	4
S&R (cm)	(-6.5)	(-5)	(-6)	(-3)	(-4)	0	0	1
VJ (cm)	49	47	48	47	44	47	47	51
Overhead Medicine Ball Throw (m)	8.5	7.3	6.9	7.2	6.3	6.14	6	5.85
7 Stage Abdominal Test	4	4	4	4	7	7	7	7
505 Agility with the ball	3.64	3.13	3.04	2.81	2.93	3.14	2.92	2.86
505 Agility without the ball	2.48	2.23	2.25	2.19	2.38	2.26	2.19	2.21
40m Sprint without the ball (s)	5.76	5.89	5.63	5.64	5.57	5.73	5.47	5.66
40m Sprint with the ball (s)	7.05	6.5	6.35	6.09	7.66	6.38	6.35	5.94
YYIR1 Test	15.5	17.1	17.5	19.2	18.8	19.1	19.7	19.7
MSFT	10.8	11.4	11.6	12.1	13.7	13.9	13.4	13.9

8.3.5 Training Components

Both Players A and B completed the same training sessions and allocated the same percentage of time to each training component. It was reported that 32% of the time was allocated to conditioning training with the ball and 18% without the ball. The remaining time was allocated to SSG training at 50%.

8.3.6 Injuries

Neither of the two players in the case study presented any injuries during the season.

8.4 Discussion

The aim of the study was to investigate the impacts of using SSG training and a soccer specific S&C program on the fitness, injuries and attendance of Australian amateur soccer players. Overall, despite the low number of players who participated sufficiently during testing and training sessions, the use of a S&C program twice per week in addition to SSG training proved successful in improving fitness and preventing injuries during the season. Seven of the 13 fitness variables improved from pre- to post-season in both of the players. In addition, both players attended 95% or more of training sessions and sustained no injuries during the season.

First and foremost, the current study demonstrated the potential problem of low attendance and compliance rates in amateur sporting teams. Although there was a high attendance rate at the beginning of the season, these numbers decreased throughout the season and consequently, only two players' results could be analysed. Therefore, although being able to use more player results was desired, the outcome allowed for the discovery of another consideration that must be taken when working with amateur sporting teams in both a researcher and coaching role.

In regards to the intervention in the current paper, there have been many research papers that have begun to investigate the use of SSG. However, although previous studies such as that completed by Mallo and Navarro (2008) have concluded that SSG can effectively develop specific endurance capacity of soccer players, there has been minimal literature investigating the effects of using SSG in conjunction with a sport specific conditioning program on the overall fitness of amateur soccer players.

There are a number of differences in the way in which amateur and professional players perform SSG, which may impact on whether or not fitness may be gained. For example, it has been concluded that amateur players require more touches on the ball per individual possession when compared to their professional counterparts (Dellal, et al., 2011; Dellal, Wong, Moalla & Chamari, 2010). Furthermore, professional players outperform amateurs in terms of physiological and perceptual responses, technical activities and time-motion characteristics in SSG (Dellal, Hill-Haas, Lao-Penas & Chamari, 2011). Thus, the general consensus may be that it is assumed that amateur players may not be able to train with SSG as successively as professional players and consequently may not receive the same fitness benefits. However, in these previous studies SSG training was the only form of training implemented with no specific soccer conditioning without the ball included. Within the current study, both a soccer specific S&C protocol and the FIFA 11+ program were included in addition to SSG training. It may then be suggested that this extra focus on fitness training may be the key factor in increasing physiological responses in players who do not have the technical abilities, such as amateur players. Indeed, both players improved in over half of the fitness variables tested following specific conditioning training during the season. Although there were no improvements in OHT or 7SAT, these fitness variables were maintained rather than diminished so it could be suggested that the intervention was successful in sustaining upper power and abdominal strength. As majority of the skills within soccer are lower body orientated, upper body strength and power was not a main focus of the conditioning sessions. However, as overall body fitness is required in soccer, the occasional exercise such as push-ups were included in the weekly sessions. Therefore, the investigator did not expect major improvements in the OH however included the test to determine if enough training was being included to maintain pre-season results. In regards to abdominal strength, the 7SAT focuses on testing the relative strength of the upper core muscles (Ski & Snowboard Australia, 2016). As the training during the season included a number of exercises that trained the entire core such as planking as opposed to exercises that focused primarily on the upper abdominal muscles, it could be proposed that by including more overall core exercises, the players may have improved significantly better in the 7SAT.

In regards to the use of the FIFA 11+ injury prevention program, the current study reported no injuries throughout the season from either of the two players investigated. Thus, it could be suggested that the inclusion of the FIFA 11+ was successful in aiding in injury prevention. In terms of physical fitness, the FIFA 11+ program appears to have assisted in improve performance in majority of fitness variables. The single-leg bounding and jumping exercises within the program likely contributed to the improvement in lower body power as evident in the VJ performance. This relationship has also been previously acknowledged by Kilding, Tunstall and Kuzmic who focused on the use of the FIFA 11+ program in young soccer players (2008). As the ability to jump high to head a ball in either an attacking or defending position is critical within the game of soccer, good lower body power is highly desired by players (Kilding, Tunstall & Kuzmic, 2008). Thus, the positive results within the current study support the use of conditioning training to enhance jumping mechanisms. These positive result however, may have also been attributed to the soccer specific conditioning protocol that was included due to the nature of the strengthening exercises and the knowledge that strong muscles and good balance and technique often prevent injuries, particularly around the knee joint (Ringo, Kelsberg & St Anna, 2011).

Additionally, the compliance to the protocols was 100% for Player A and 95% for Player B. As compliance is a known factor for whether program such as the FIFA 11+ works effectively or not, it is proposed that by the players having a high rate of program completion, they were receiving the full benefits that come alongside participating (Krist, van Beijsterveldt, Backx & de Wit, 2013). As amateur teams often don't have the funding or accessibility to sources of medical assistance such as doctors or physiotherapists, injury prevention is highly desired to avoid players needing assistance (Grove, Lavallee & Gordon, 1997). Therefore, it can be suggested that with positive evidence such as that shown within the current investigation, future coaches can feel confident in utilising such protocols within weekly training sessions to prevent injuries during the season. Although majority of the players within the current squad did not completely fulfil the results of the program of fitness testing, the results of these two players gives strong support to show that this soccer specific S&C program can work if implemented correctly. Additionally, as the current protocol was performed approximately two times a week for half an hour, it can be established that amateur athletes have the ability to overcome time constraints and undertake S&C training should the coach allow for participation within normal training time. However, it is unknown if the same positive results would occur should the training have to be completed outside of normal training hours. Due to already tight time constraints of amateur players, it is advised that coaches should be encouraged to include conditioning training within normal sessions where possible in order to provide the most encouraging environment possible for significant improvements to occur.

8.5 Practical Applications

It is recommended that in order to increase fitness and prevent injuries in amateur soccer players, a training program including both SSG and a S&C protocol comprising of strength exercises and the FIFA 11+ be implemented throughout a season. A periodised approach should be utilised whereby during the off-season, strength, balance and proprioception exercises be implemented to maintain fitness to prepare the players for the upcoming season. During the season, non-ball soccer specific conditioning should be implemented in conjunction with SSG training to aid players in improve on the fitness maintained during the off-season. In addition, it is advocated that coaches consider the skill and tactical ability of their players when implementing SSG training before deciding how much time to allocate to this type of training.

Additionally, it is suggested that there be further investigation into the potential problems S&C coaches and researchers can face when working with amateur athletes such as attendance and compliance rates in order to assist future professionals.

9: Psychological, Physiological and Training Program Considerations when Working with Amateur Teams and Coaches

Chapters 3, 4, 5, 6, 7 and 8 identified a number of issues that may arise when a S&C coach works with amateur sports coaches and teams. Consequently, this chapter provides a discussion of these problems and gives recommendations for S&C coaches, particularly those new to the field, of how to deal with the potential obstacles that may occur throughout a season. The objective of the chapter is to provide a scaffold for new S&C coaches to follow and provide a means for them to be proactive, rather than have to be reactive when problems arise.

Hervert, S.R & Deakin, G.B. (In Press). Psychological, Physiological and Training Program Considerations when Working with Amateur Teams and Coaches. *Journal of Australian Strength and Conditioning.*

9.1 Introduction

It can often be challenging for a new strength and conditioning (S&C) coach when they are faced with overwhelming situations such as working with large groups of athletes or sports coaches who don't understand the role of S&C. This discussion piece is aimed at providing examples of real life scenarios that are common in S&C coaching at the amateur level, and possible ways in how S&C coaches may address them proactively, rather than reactively. The purpose of this article is to not only offer solutions, but to also encourage the S&C coach to think about their own individual environment and how they may deal with difficult situations, should they arise.

Based on the competitive level of athlete's, S&C coaches must adapt a different leadership style in order to encourage a productive coach-athlete relationship (Magnusen & Rhea, 2009). This is to take into account the many considerations that come with differing levels of athletes including both physical and mental variances. Literature states that there is a physiological difference between speed and agility performances in professional and amateur soccer players with latter performing significantly worse than their counterparts (Kaplan, Erkmen & Taskin, 2009). Differences also exist in mental and psychological aspects with professional athletes having a higher self-esteem and mental health (Samadzadeh, Abbasi & Shahbazzadegan, 2011). Furthermore, Casper and Andrew (2008) determined that more advanced players reported significantly higher levels of commitment to sport than lower level and intermediate players. A number of studies have also concluded that athletes at the amateur and community level have a higher injury rate per 1000 hours than those at the professional level in a number of sports including boxing, hockey, basketball, netball and football codes such as soccer and rugby league (Finch, Costa, Stevenson, Hamer & Elliott, 2002; Gissane, et al., 2003; Morgan & Oberlander, 2001). This becomes especially important if coming from a situation of dealing with professional athletes at the elite level as evidence suggests that leadership styles of S&C coaches varies between differing competition levels and evidently, a "one size fits all" approach is not appropriate (Magnusen & Rhea, 2009).

Another essential consideration when working with amateur teams is that S&C coaches need to work efficiently and effectively in conjunction with the sport coaches. Anecdotal experiences have suggested that the S&C coach is part of a collaborative group of coaching staff that works closely together. If the S&C coach is not in sync with the thoughts and beliefs of the sports coach, their job may be at stake (Dawson, Leonard, Webner & Gastin, 2013). Thus, not only is it important for the S&C coach and the sports coach to communicate effectively for the athlete's sake, but also to ensure job security.

Whilst there has been previous research on the S&C coach's relationships with athletes and the sports coach that may assist in beginning to understand the considerations that must be taken to successfully coach athletes, there has been minimal exploration into how these relationships exist within the amateur level, particularly in Australia. As there has been much research in the differences between levels of competitive athletes, it is important that coaches understand that different coaching tactics may be required when coaching amateur athletes (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011; Franchini, Takito, Kiss & Strerkowicz, 2005; Toering, Elferink-Gemser, Jordet & Visscher, 2009).

Additionally, there has been minimal research into the relationship of the S & C and athletes. Due to the increasing number of S & C coaches worldwide, there is a need for further exploration into the dynamics and understanding of this relationship.

Thus, this article discusses potential problems that may occur when coaching amateur athletes and will offer recommendations in how to approach real-life coaching situations.

9.2 Considerations for working with amateur players

9.2.1 Athlete and S&C coach relationship

The interactions between a player and a coach can vary from day to day and the relationships are often complex. However, in order for sporting success, coaches must encourage athletes to act in appropriate ways and complete set tasks adequately (Rylander, 2015). This statement was originally written in regards to team sport coaches however, it can be applied to the S&C coach setting as they too, often have to deal with similar player-coach scenarios. Athletes suggested that compatibility with their S&C coach is highly important as those with a positive relationship often report higher perceptions of their athletic training environment and thus, are more likely to perform better (Lee, Marshall & Cho, 2013). Thus, it is important to discuss the different ways in which a S&C coach can enhance the relationship they have with their respective athletes.

Although there is minimal literature discussing how a S&C coach's behaviour can influence an athlete's motivation and satisfaction, there has been recent research into how the sport coach's power and ability to influence athletes may affect the coach-athlete relationship (Rylander, 2015; Vazou, Ntoumanis & Duda, 2006). It is known that there are a number of different types of power that a coach may have within the relationship including superior knowledge, power to influence, coercive and award power, and informational power (Rylander, 2015). However, often these powers are based off what the athlete perceives to know about the coach. For example, if the coach is a former elite athlete, they are likely to be perceived as an expert or role model (Rylander, 2015). Similarly, if the coach is known to have been a player of the sport in question, the athlete's will often buy into what the coach has to say rather than someone with no personal experience. These circumstances are great should the coach possess the adequate "qualities" the athlete's deem to be worthy however in the scenario they don't, problems can begin to arise. The coach must then reassess how to approach the relationship and consider how to do their job (coaching) effectively to assist in getting the athlete or team to succeed. All of these key points regarding the sport coaches relationship with athletes is also applicable to that of the S&C coach and athletes, with 'buy in' power being highly important in encouraging athletes to perform the tasks set for S&C training appropriately.

It is also important for S&C coaches to understand the variances that come with working with differing sports such as using the specificity model for S&C requirements and psychological differences (Gamble, 2013). For example, it is not appropriate to provide gymnasts with the same S&C exercises as soccer players. A professional level S&C coach known as Michael, previously stated that there was a difference between the rugby culture and that of AFL (two team sports) and the way in which the players accepted the S&C coach. He mentioned that "the rugby culture was easy" and that they "gave you respect straight up". However, the AFL players made you earn their respect, regardless of how much experience you had or what you had done elsewhere (Dawson, Leonard, Webner & Gastin, 2013). This provides an interesting insight into the differing levels of acceptance between sports even if similar traits exist between them. This consideration is especially appropriate for S&C coaches at the amateur level as coaches of this level are often not full-time coaches for one single sport and instead, are involved with a number of sports. Thus, it is essential to understand that each sport must be treated specifically and individually.

Furthermore, coaches must consider the background characteristics of their athletes, especially when changing from one group of athletes to another. For example it is important that coaches consider the differences between working with female and male athletes as the latter have been reported to be less compliant due to potentially thinking the coach does not have superior expertise (Magnusen & Rhea, 2009). In addition, it is also important for the coach to contemplate their own gender as this can also create boundaries with the players. For example, a female coach who is to work with a male rugby union team will often face a lack of athlete “buy-in” simply due to her gender or the fact she may not have been involved in the sport before. Therefore, in this situation the S&C coach must work towards proving her worth to be accepted by the athletes. This can be done in a number of ways including demonstrating her knowledge about the game and S&C. This situation can also occur vice versa with male S&C coaches and female athletes. A male S&C coach who walks into a netball academy will often face the same unsure group of players as the previous example. Again, the best way to gain acceptance is for the S&C coach to prove they have the capability to do the job.

Players who are non-starters are also more likely to comply due to the belief the coach has the “power” and those athletes who have been in longer relationships with their coaches are often more compliant (Rylander, 2015).

In order to gain the respect of athletes, the S&C coach must also return the favour and pay respect to them. One of the best ways to do this is to incorporate positive coaching behaviours in their daily interactions with the athletes. Implementing positive coaching behaviours will also assist the S&C coach to enhance the athletes’ perceptions of the relationship compatibility discussed previously. One way in which to implement positive coaching is to provide constructive criticism and emphasize what needs to occur next time, rather than focusing on the athletes mistakes. Additionally, S&C coaches should avoid distractive and disruptive actions such as standing over the athlete or hovering around them as they train. To enhance this, the S&C coach should also use positive body language to encourage confidence (Lee, Marshall & Cho, 2013). For example, the S&C coach should display enthusiasm and passion to encourage motivation for the athletes through the use of open body language such as avoiding slouching or turning their back. Additionally, the tone and language a S&C coach uses is vital in inviting the athletes to be interactive with them. The S&C coach should use positive words and avoid harsh or sarcastic tones, as this will turn players off wanting to listen or follow instructions. These are all simple yet effective ways to assist in building the relationship with the athlete and gaining their respect. Fortunately, all of the aforementioned strategies are effective and easy to implement at the amateur level and should be utilised on a regular basis in training sessions.

9.2.2 Athlete Education and Experience

Often at the amateur stages of competition, players demonstrate a lack of knowledge in regard to S&C procedures and what they are utilised for. For example, amateur players are generally uneducated on the importance of rehabilitation and recovery protocols for both injured and non-injured players. Occasionally, an athlete may understand the general concept but not the practical science behind an exercise and thus, will question the importance of completing the task. When athletes begin to question the utilisation of exercises is when problems begin for the S&C coach as the athlete's demonstrate a lack of 'buying into' what they are selling. It then becomes part of the S&C coach's job to educate the players on the importance of concepts such as building strength, power, aerobic capacity, speed, and flexibility. Additionally, the players need to understand why incorporating recovery and rehabilitation protocols into their training schedule is necessary. For example, explaining to athletes that recovery techniques may help in reducing injury rates and therefore, allow them to train and play more will often encourage them to participate more as they appreciate how it will benefit them. Often, by explaining the benefits for them as individuals, players are less opposed to the idea of more 'work' and some will even begin to enjoy the educational aspect of participating in S&C.

Similarly, athletes at these levels often have very little experience with S&C, if any at all. This means that their respective training age is often very low and it will take the S&C coach additional time to teach and implement exercises with them. Additionally, S&C coaches have to be cautious when choosing exercises to implement with novice athletes due to their inexperience as it may take longer to teach them in comparison to dealing with more advanced athletes (Baker, 2001). These considerations are especially important to reduce a heightened risk of injury and implement exercises that are appropriate for the lower levels of S&C skills and experience in novices (Baker, 2001). For instance, incorporating simple body weight exercises may be appropriate for novices as they allow for minimal weight and maximise technique development. Furthermore, S&C should be incorporated throughout the entire training period to allow athletes to have as many opportunities in S&C experience as possible.

9.2.3 Athlete Attendance and Compliance

A major issue that occurs especially at the amateur level in particular is the low levels of compliance that can be associated with the lack of knowledge and outside of sport commitments that athletes demonstrate. This lack of compliance can be in terms of overall attendance or the athletes choosing not to participate sufficiently enough to gain the benefits of the program. Thus, it can often be hard for S&C coaches to see the full effects of a program that has been implemented when athletes are not compliant or do not complete it properly. It can then be hard to determine if the program is in fact working or if not, what needs to be changed in order to enhance it.

Attendance and compliance issues can also impact on the gathering of data on fitness performance to determine strengths and weaknesses. For example, when athletes are absent from training, a team's data set cannot be complete due to some results not being recorded. Additionally, athletes who are not 100% compliant due to laziness can also mean some results are inaccurate and thus, cannot be used for analysis. Again, these erroneous results can make it difficult for the S&C coach to alter training programs as planned following fitness testing.

These attendance and compliance concerns must be addressed prior to the training season beginning and it is often best if the sports coach supports the S&C coach in discussing with the athletes what is expected from them during the season. One example may be that in the initial training session or meeting with the athletes, both the sports coach and the S&C coach present some ground rules for attendance and effort during all sessions in the season to come. Suggesting some rewards for effort throughout the season such as starting positions, can also help support the cause in situations with amateur teams. Ideally, the sports and S&C coach's as well as additional performance staff should work together to implement this strategy as a harmonious group.

An additional difficulty that occurs often at the amateur level is the fact that it can take a couple of months into the season until athletes for teams or groups of athletes are officially determined. Often, players still come into and out of a team until half way through the season. This can cause issues for the S&C coach as although the core group of players may remain the same, there are still a number of players who will not complete the S&C training on a weekly basis and will thus, miss out on the full effects of finishing the entire program. Moreover, the S&C coach will have to implement the entire learning process over again for those new athletes to the program. Unfortunately, this can't often be avoided so it is suggested that S&C coaches offer alternative and beginner exercises for new athletes in the meantime whilst trying to get them up to speed with the rest of the team.

9.3 Considerations for Working with Amateur Sport Coaches

9.3.1 Coach and S&C coach relationship

With an increasing number of S&C coaches being hired within high school, collegiate and professional athletic programs, it is important that a strong relationship is established not only with the athletes, but also with the sports coach or athletic director (Magnusen & Rhea, 2009). However, there are a number of underlying factors that can hinder the development of this relationship.

The role of a S&C coach differs to that of a sports coach although the two may have a cross-over from time to time. Ideally, the S&C coach provides a service to athletes by testing, evaluating and then prescribing appropriate training and exercise to enhance athletic performance. Additionally, they incorporate injury prevention and rehabilitation training when required (Baechle & Earle, 2008). The sports coach however, is often the leader of the team and controls more skill and tactical training in addition to being the one to make game play decisions (Loughead & Hardy, 2005).

A S&C coaches performance is often dictated by the athletes performance and as such, the programs implemented must have contributed to improving the physical performance of an athlete in fitness variables such as strength, flexibility, power, speed and agility. Thus, in order for the S&C coach to gain the respect of the sport coach or athletic director, the athlete or team generally has to perform well physically (Magnusen & Rhea, 2009). More often than not, the level of knowledge a S&C coach has is also correlated to the level of respect a sports coach will have for them. For example, having a higher level of knowledge will often allow the S&C coach to be involved with more discussion and decision making with the sport coach. This is particularly important when decisions are being made in regards to the periodisation and annual plans of the athletes, for when the two coaches work together, the training plans often run a lot more smoothly and success generally follows. However, despite this wanted need for mutual respect from the sports coach, S&C coaches often state that they have a perceived lack of respect and appreciation from them (Dawson, Leonard, Webner & Gastin, 2013). This is common especially at the amateur level as the S&C coach is often perceived as an ‘add-on’ rather than a ‘necessity’ by other coaching staff. In order to combat this common thinking process of the sports coach, it is essential to attempt to educate them on the importance of the role of the S&C coach and what they can bring to the table in terms of increasing athletes performance. It is best to explain the many key aspects the S&C coach can implement in addition to physical performance such as providing injury prevention and rehabilitation techniques, recovery education and implementation tools, and fitness testing and analysis.

Another difficult task the S&C coach has to overcome working with an amateur sports team is that the sports coach generally has the power when it comes to designing the type of training sessions that take place. Regularly, the sports coach will have a number of requests as to what should be involved within the sessions and these can often be quite restrictive on how the S&C coach designs their programming. For example, within a team sport at the amateur level there are generally two to three training sessions a week and a competitive match on the weekend. Within this situation, the sports coach may request that there be no strength or power training during the competitive season as the players experience too much muscle soreness to perform adequately in games. This then creates problems for the S&C coach as it is known conditioning must be trained to be maintained and essentially, fitness that has been built up during the preseason will be diminished if not trained (Rønnestad, Nymark & Raastad, 2011). Again, it is important to educate the sports coach and players to understand that although they may experience muscle soreness and fatigue at the beginning of the season, these feelings will eventually dissipate if training is continued as the body adapts (Cheung, Hume & Maxwell, 2003). It is suggested that S&C coaches utilise data and research that is at their disposal to assist them in educating sports coaches on the importance of maintaining fitness conditioning during the season and how it will benefit the athlete’s performance. Such evidence includes fitness testing data that demonstrates diminishments and improvements in fitness following cessation and continuation of training throughout the season respectively.

Furthermore, sports coaches will often want to focus on sport specific training rather than S&C training within settings such as gymnasiums if they are available. This is common especially in team sports such as soccer, rugby league and basketball (Foster, Twist, Lamb & Nicholas, 2010; Hill-Haas, Dawson, Impellizzeri & Coutts, 2011; Sampaio, Abrantes & Leite, 2009). It can become difficult to convince the sports coach that additional S&C training is necessary as they often believe that they are already covering fitness on all bases. However, as evidence exists that amateur level athletes cannot complete small-sided games training at a high enough intensity to gain fitness benefits, it is crucial that sports coaches understand the importance of including some form of S&C within their training schedule (Dellal, Hill-Haas, Lago-Penas & Chamari, 2011). Often the best way a S&C coach can gain coaches belief in conditioning training without the ball is to prove how important S&C is for the player's performance. For example, it is important that the S&C coach demonstrate their ability to both improve fitness and prevent and rehabilitate injuries. These demonstrations often appeal to both coaches and players and allow opportunities for the S&C coach to implement strength, stability and proprioception exercises that will also aid in improving fitness as well as injury prevention and rehabilitation.

Although sports coaches at the professional level of sport generally periodise their training programs, amateur coaches rarely do possibly due to the lack of education that exists, that they simply don't deem it necessary or find it hard due to athletes being involved in more than sport at a time (Lee, Marshall & Cho, 2013). In the case they don't periodise or plan training sessions or programs, the S&C coach can be left essentially "in the dark" as to how much load the players will typically be under and how to design the S&C training sessions. Additionally, due to the unknown load the players are under, there is also an unknown injury risk and possibility of under- or over-training that exists. Thus, in order to ensure that these risks are minimized as much as possible, the S&C coach must work closely with the sports coach to at least gain a rough overview as to what the sports specific training will look like during the coming week at a minimum. This will allow the S&C to at least have an idea as to how to design their session. However, it is important to remember that just like any level of sport, the sports coach can and will decide to change their mind at the last minute. Thus, it is always best to have a back-up plan to ensure that the athletes still receive some form of S&C training during each week, even if it means simply assigning some "homework" for them to complete outside of training.

Finally, the possible lack of knowledge sports coaches may have often extends to understanding information regarding injuries and rehabilitation and recovery protocols. Generally, many players at the amateur levels will return to sport too soon after sustaining an injury and often the re-injury rate is high due to many players never fully recovering. As the coach is generally the final say in when a player can return to sport, it is vital for the S&C coach to educate them further in how players must undertake an appropriate rehabilitation program if they are injured. Additionally, further education of how adequate recovery methods following training and games can assist in injury prevention will contribute to the cause for the S&C coach to be an indispensable asset to the sports performance team.

9.4 Additional problems S&C coaches face

9.4.1 Time, Accessibility and Financial Constraints

Players and sports coaches at the amateur level also have a number of constraints such as time, life, work and family commitments, accessibility to appropriate facilities and equipment and financial availability. These constraints can cause a number of issues for the S&C coach and it is vital to be able to react promptly when they arise to create the best environment possible for the athletes to train and perform in.

Generally, athletes and sports coaches receive minimal to no payment for their participation in amateur sport (Maier, Woratschek, Ströbel & Popp, 2016). Unlike other countries such as the United States of America where athletes and sports coaches are offered salaries or game based payments, sport at the amateur level in Australia does not provide athletes the opportunity to participate in their sport as a full-time or even a part-time job. This is because occasionally, even elite athletes do not receive appropriate payment so it is not expected that amateurs will (Maier, Woratschek, Ströbel & Popp, 2016). Thus, they must usually undertake paid jobs or be involved in some sort of study to have financial support for everyday living.

This lack of financial incentive can allow for talented players to “hide” within S&C training, as their skills are often the ability that is going to get them more minutes on the field as opposed to their fitness. This is especially applicable if the sports coach deems talent to be more desired than fitness, which is often the case within team sports such as soccer. To avoid athletes “hiding”, S&C coaches should aim to design training sessions that incorporate each athlete equally to avoid the prospect of anyone being able to ‘hide’. This may involve working in pairs or small groups that requires the athletes to work both individually and as a team. For example, if the training session focuses on high intensity anaerobic training, the S&C coach may divide the athletes into groups of three (A, B, C). Athlete A will complete an interval run of a desired distance while athletes B and C rest. Athlete A will then return to tag athlete B and the drill would continue on for a determined time or number of repetitions. In regards to gym-based sessions, a similar approach can be applied by pairing athletes up to complete their sets. For example, one athlete would complete the set while their partner rests. The athletes would then switch positions over. This method can also help to enhance athlete motivation and team chemistry, and allows for full utilisation of the limited equipment that may be available. By incorporating drills such as those mentioned above, S&C coaches are addressing the issue of players potentially ‘slacking off’ which in turn means that each individual is getting conditioned appropriately.

Often, athletes and sports coaches may also have to support a family and therefore, their respective sport may not be a first priority. This circumstance is all too common and results in various problems for the S&C coach. One of the most frustrating issues is that the training timetable is often determined by their work or families schedule as opposed to what the S&C coach prescribes. This can make it difficult to train adequately as the athlete’s have less face-to-face time with both coaches and this can be particularly detrimental to fitness and conditioning training. In order to address the attendance issue, S&C coaches are advised to set specific conditioning training that the absent athlete can perform in their own time such as body weight circuits or aerobic intervals. However, it is important to remember that these athletes are not full-time professionals so keeping the workout short but intense will often illicit a greater adherence and response. Additionally, most amateur athletes will only train two to three times a week so it is essential to keep training sessions precise and use the time wisely. In a team sport such as soccer for example, the S&C coach may decide to increase the intensity but decrease the duration in a session during the competitive season to maintain the same volume they would utilise during a pre-season session. This technique showcases good coaching that has taken into consideration the time constraints and the focus of the session.

In addition to time constraints, amateur sports coaches and players also have less accessibility to good facilities with adequate equipment for S&C training sessions such as gyms or well-maintained fields. This lack of opportunity can put limitations on how the S&C coach designs sessions and often, they have to be creative in the exercises prescribed. Importantly, the S&C coach also has to consider the possibility of an increased injury risk due to the training environment being insufficient such as uneven grounds or older equipment. It is suggested that S&C coaches always have a Plan A, B, C and so on. Circumstances such as weather conditions or multiple teams utilising the same field can play havoc with a planned training session so it is essential to ensure there is always a backup session in place. This back up plan will of course depend on the opportunities and financial situations of a particular organisation or team and often the contingency plan the S&C coach decides on will be based on these constraints. In these cases, it is suggested that the S&C coach plan a substitute session that does not require much space or equipment such as stretching and recovery session or a simple body weight circuit that can be completed in a stationary position for the athletes. It may involve some research and resourcefulness but also allows for collaboration between other S&C coaches who are in the same situation. Utilising the internet and text books becomes very useful as does designing their own exercises that are focused on their respective sport. Please refer to the provided short list below of recommended websites and textbooks that may be useful in assisting with training session contingency plans.

9.5 Recommended Websites and Useful Textbooks for Training Session Contingency Plans

- **Planning a Training Session (Australian Institute of Sport)**
  http://www.ausport.gov.au/participating/resources/coaches/tools/the_training_session/Planning
- **Planning and reviewing- a training session (Softball Australia)**

http://assets.softball.org.au/dl/sal/Coaching/Resources/Planning%20and%20reviewing%20a%20training%20session.pdf

- **Get creative with circuits**

  http://www.ideafit.com/fitness-library/get-creative-withcircuits

- **Optimising effective cross-training methods**

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One other problem S&C coaches often face when dealing with amateur athletes is that due to their other commitments, there are more factors within their lives that may impact on their mood. Consequently, S&C coaches may become more stressed if the athletes or sports coaches present with a bad mood as they have arrived at training after having a bad day or similar. Previous S&C coaches have discussed that coping with demanding and aggressive athletes is a main stressor of their job and that when an athletes speaks to or treats them in an undesired way, they can end up taking it home (Dawson, Leonard, Wehner & Gastin, 2013). In order to deal with these potential stressors, the S&C should be proactive rather than reactive by tackling the problem head on at the beginning of the session. Simply asking the individual if they are okay whilst avoiding questions that are too personal will often allow them to open up, possibly vent and improve the mood. If the individual does not want to talk, the S&C coach should encourage them to try and keep their life outside of sport separate to training sessions and games by "leaving the feelings at the door" when they arrive. This can also be encouraged by starting the session straight away to avoid the individual potentially placing their mood onto others. In doing this, the S&C coach is releasing the possible tension that was in the air and allowing the session to continue without further interruption to other athletes.

9.6 Practical Applications

Although there are many potential issues that must be taken into consideration when working with amateur athletes and coaches, there are many ways in which the S&C coach can deal with them accordingly.

One of the main methods in which the S&C coach can assert their place within amateur sport is to educate both the players and the coaches on the importance of conditioning training, injury rehabilitation and recovery. At these lower levels of professionalism, it is important to point out that S&C training doesn't have to be hard or take up too much time as this will gain more "buy-in" from the players especially.

Additionally, S&C coaches should always attempt to be prepared both on a seasonal and daily basis whilst working in conjunction with the sports coach. It is essential to always have a back-up plan, alternative plan and even a stand-in plan to cover all bases for things that may potentially happen. By taking the time to prepare, this may again work in favour of the S&C gaining respect from the sports coach and players.

Overcoming a lack of education, respect and general understanding of the S&C coach's position is often the hardest part of dealing with amateur levels of sport but by being proactive rather than reactive, there is a good chance the S&C coach may become recognised as playing a key role in developing the athlete's performance.

10: Discussion, Future Directions and Conclusions

10.1 Discussion

There have been numerous research studies that have investigated the seasonal variations in fitness in soccer players with varying results including both positive and negative conclusions in regards to fitness improvements (Caldwell & Peters, 2009; Kalapothrakos, Ziogas & Tokmakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009). However, the majority of this research has been completed on adult soccer players in Europe and North America with minimal literature existing on players within Australia, particularly at the sub-elite level. Therefore, the aim of this project was to investigate the seasonal changes in fitness throughout a season in Australian sub-elite soccer players at both the youth and adult level of competition. Additionally, a secondary purpose of the study was to determine the factors that contributed to the outcome such as training session structure, training/game attendance and injuries of the players.

Overall, the current project concluded that there are minimal, if any improvements in fitness variables over the course of a soccer season in Australian sub-elite players. This lack of change in performance was influenced by a number of factors including the high use of SSG training, issues with attendance and compliance levels and injuries. However, when the investigation was implemented in sub-elite players in Chapter 8, it was found that those players who gave a high level of compliance received the full benefits of the S&C program and improved in many fitness variables as well as not sustaining any injuries. Thus, it would appear that with adequate compliance from the coach and players, a soccer specific S&C program can be successful in aiding fitness improvements and injury prevention.

Throughout the completion of the individual studies, there were a number of findings and issues that arose with the majority of these already being discussed in Chapter 9. Thus, this chapter's discussion will only briefly review the overall findings from all studies including those established on seasonal changes in fitness, training structure and injury issues and additional findings that occurred.

10.2 Seasonal Fitness Discussion

It was demonstrated throughout numerous chapters within the project that there were minimal to no significant improvements in fitness variables. These results were seen in both adult and youth players as shown in Chapters 3, 4, 5, 7 and 8. For example, although both the male and female youth players improved significantly in YYIR1, there were no other significant improvements in fitness at post-season. Additionally, there were significant differences in the changes in some fitness variables between male and female youth players with the latter performing significantly worse in VJ and 505 agility performances both with and without the ball when compared to their male counterparts (Chapter 5).

These results were similar to previous research by Mujika, Santisteban & Castagna (2009) who reported that junior male soccer players performed significantly better than females in a number of fitness variables. The current differences could be influenced by a number of factors including the difference in training the players undertook that exist between males and females (Rampinini, et al., 2007). The previous chapters demonstrate the important point that the females investigated within this thesis did not perform any conditioning training at all during the season. In contrast, their male counterparts performed conditioning training, which may have lead to the improvements in fitness variables reported. Chapter 7 presented similar findings with no significant changes in any fitness variables in both the control and intervention teams although the latter increased body fat percentage. Both teams showed a lack of change in fitness performance from pre- to post-season. There are a number of reasons as to why fitness may not have improved in the players within this investigation such as problems with training session design, injuries and player and coach compliance and these will be examined further within this discussion.

However, another issue that was found during this project was that players appeared to be entering the competitive season having participated in minimal if any conditioning training during the off-season and pre-season. This was particularly evident in Chapters 3, 4, and 5 when players did not undertake pre-season training. During these seasons players not only have no change or deteriorated in the majority of the fitness variables, but the majority of injuries were also sustained during the first half of the season. This suggests that fitness should be at least be maintained during the off-season and ideally increased during the pre-season periods to ensure that players are prepared for the competitive season to come.

Whilst Chapter 8 only discussed the results of two players, it demonstrated the positive effects pre-season S&C training can have when undertaken in conjunction with competitive season training. It was found that the program was effective in not only improving fitness in a number of variables but also by reducing the risk of injuries when full compliance by players was given. Although only two players were able to completely fulfil the requirements of the program, the results showed that no deteriorations in fitness and no injuries sustained over the entire season. In particular, it was found that during the season in question, coach and player education was higher than in other seasons as the investigator was able to become a lot more involved in training session design and implementation and therefore, a strong S&C impact was made on the team during the season. The importance of this interaction was outlined in Chapter 9 with the considerations of dealing with amateur teams being discussed in detail.

10.3 Training Session Design Discussion

In regards to training session design, the majority of research has suggested that individual teams appear to structure training sessions differently depending on their location and the level of competition and players (Arziz, Tan & The, 2005; Kalapotharakos, Ziogas & Tomakidis, 2011; Magal, Smith, Dyer & Hoffman, 2009; Silvestre, et al., 2006). Indeed, this project demonstrated the different ways in which coaches design training sessions and allocated training time in Chapters 4, 6 and 7. Since elite teams have reported a high use of SSG training in their weekly sessions, it has also become evident that many amateur teams are beginning to adopt the same approach to training (Bunc & Psotta, 2001). However, as these professional teams generally have a higher number of training sessions per week, it is not appropriate for amateur teams to attempt to replicate the same training styles and expect the same results. The current investigation did show that sub-elite and amateur coaches were quite uneducated in how to periodise programming in an efficient manner that allows for both fitness and skill improvements during the season. The results from this project demonstrated that amateur and coaches prefer to use SSG for the majority of training session time.

Although a primary focus on SSG may assist youth players in skills and tactical development, it was found that sub-elite and amateur teams are utilizing them too much during the season and there is a lack of specific conditioning and injury prevention training that exists. This lack of conditioning was evident in a number of results found in Chapters 3, 4, 5 and 7. Although previous literature has provided evidence that this SSG approach works with elite players in European countries, it was found in the current studies that sub-elite and amateur Australian players do not possess the skills or abilities to complete this training at a high enough intensity to illicit fitness improvements during the season (Castellano & Casamichana, 2010; Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson & Roswell, 2010; Mallo & Navarro, 2008). In Chapter 7 a soccer specific S&C program involving use of the FIFA 11+ program and MAS training was implemented as it had been successful in improving aerobic performance in elite European soccer players (Dupont, Akakpo & Berthoin, 2004). However, the coach still insisted on SSG making up the majority of the training session whilst the specific conditioning accounted for only 8% of training session time. Therefore, as the conditioning component made up such little time of the session, it can be suggested that the training session design could still have been improved to increase the likelihood of increasing fitness. This was demonstrated particularly in Chapters 7 and 8 with improvements found in some fitness variables following the introduction of soccer specific S&C training. These results were similar to those found by Magal, Smith, Dyer and Hoffman (2011) who concluded that minimal improvements were found in an NCAA soccer team who undertook mainly SSG training with minimal S&C. However, in Chapter 8 where the investigator was able to have a much larger part of the training session time to work on S&C, the compliant players improved in fitness throughout the season. Indeed, the players had a focus on conditioning training for 50% of total time spent at training which when compared to previous Chapters, amounts to nearly five times as much training time. Additionally, 18% of this 50% was specifically conditioning without a ball, which further supports how the improvements in fitness were gained. `

Another major problem that appears to exist when working with sub-elite teams is the low compliance levels among both coaches and players. A number of issues arose due to the lack of compliance from coaches and players and these were found to have played a role in the less than desired results. For example, the differences in fitness changes between the male and female players in Chapter 5 were deemed to be attributed to the variances in training session structure between the teams with the males performing 41% more time training conditioning than the females who completed none throughout the season. This difference may have contributed to the substantial variance in seasonal changes in VJ performance between the two teams as although the females deteriorated significantly, the males were able to maintain pre-season results. These results are a key note as they may demonstrate the importance of utilizing training session time adequately as although males performed less overall training minutes than the females, they participated in more conditioning time which may have assisted in their performance maintenance. Additionally, both teams within Chapter 5 appeared to enter the competitive season with minimal pre-season conditioning training and thus, sustained 80% of the season's injuries during the first half of the season. This high number is in contrast to previous literature stating that the majority of injuries generally occur in the latter half of the season once players begin to fatigue (Giza, Mithöfer, Farrell, Zarins & Gill, 2005). Therefore, the time of conditioning training implementation becomes an important issue, especially in sub-elite and amateur players where the off-season period is long. Chapter 7 also demonstrated issues that were influenced by a lack of compliance from the coach and players. Due to barriers such as injuries and a last minute change of mind from the coach, some fitness tests were unable to be performed during the seasons and consequently, no data could be collected. This was not ideal as comparisons could no longer be made from pre to post season or between seasons, leaving gaps in the results presented.

This demonstrated lack of compliance particularly became an issue when attempting to implement a fitness or injury prevention conditioning program as demonstrated in Chapter 6 and 8. For example, in Chapter 8 it was found that only two players were compliant for the entirety of the season for a number of different reasons such as injury factors, changes in the squad players and general lack of participation. It was also found that although overall attendance rates at training sessions were high at the beginning of the season, these numbers decreased throughout the season. Although only two players results were able to be utilized, the low attendance rates resulted in interesting discussion questions regarding the reasons why sub-elite teams are often hard to work with in both a research and S&C setting.

10.4 Injury Discussion

Within this thesis, injury data was collected and included as they were deemed to be an important influencing factor on seasonal fitness throughout a season. However, they were one of a number of factors including attendance and training structure that together, contribute to the results. Conclusive analysis could not be completed due to the low number of injuries reported during data collection.

Overall, all injury information within this project supported previous research that lower limb injuries are the most common body site locations injured in soccer players (Yard, et al, 2008). However, there were minimal injuries to the hamstring region, which is considered uncommon as soccer is known to have a high demand of speed and power (Askling, Karlsson & Thortensson, 2003). Nonetheless, all lower body muscles were conditioned in addition to the core muscles within the soccer specific S&C program which incorporated the FIFA 11+ injury prevention exercises. Chapter 6 demonstrated that this soccer specific S&C program was successful in decreasing the severity of lower limb injuries as well as the days lost due to injury (decreased by 43%) in male sub-elite soccer players. The most common injury site was the lower extremity at over 78% both with and without S&C intervention and this was consistent with previous research by Faude (2013) who reported that up to 90% of injuries reported are in the knee, ankle or thigh. Overall, the soccer specific S&C program was particularly effective in reducing the occurrence and severity of knee injuries such as those concerning the ACL. This finding was promising as ACL injuries are common in soccer and are often considered to be career or season ending (Walden, et al., 2012). This finding also supported research by Silver et al. (2014) who reported a significant decrease in hamstring and ACL injuries in soccer players at the NCAA level in the United States following a S&C program designed to reduce injuries.

When the soccer specific S&C program was introduced in Chapter 6, it did not have an effect on the type of injuries that occurred as both the pre-intervention and post-intervention results demonstrated similar injuries occurring such as muscle and bone injuries. However, there was a reduction in the number of ligament-based injuries following the intervention. Importantly, the majority of the injuries sustained during the project were contact injuries whereby players were injured during contact with another person or object such as during tackles or collisions. As the specific conditioning program mainly focused on reducing non-contact injuries, it can be suggested that more exercises focusing on contact injuries may have had more of an impact on reducing these types of injuries. However, Chapter 8 proved that the soccer specific S&C program can be successful in reducing injuries altogether should the players show a high level of compliance. These findings support previous conclusions that programs such as the FIFA 11+ and the current soccer specific S&C program require high compliance in order to be successful (Krist, van Beijsterveldt, Backx & de Wit, 2013).

In terms of the time at which the injuries occurred, previous research has suggested that majority of injuries in soccer occur during match or game play and indeed, Chapters 6 and 7 support this statement reporting that a soccer specific S&C program reduced injuries per 1000 match hours by 16% (Grooms, et al., 2013). Additionally, although there was an increase in injuries per 1000 training hours, it was very minimal. However, Chapter 5 reported conflicting results stating that the youth players actually sustained fewer injuries during matches than during training sessions. This may possibly be due to the fact that youth games are often performed at a lesser intensity than that of their adult counterparts and thus, less chances for injury occur (Mujika, Santisteban, Impellizzeri & Castagna, 2009).

Re-injuries were also common in sub-elite and amateur players with Chapter 6 stating that although quadriceps injuries increased during the intervention season, players were returning to sport too soon and re-injuring themselves. For example, 60% of injury time lost due to quadriceps injury was due to re-injury, proving cause for concern on the lack of education about recovery and rehabilitation in both coaches and players. However, it is important to note that in regards to the current thesis, the investigator had no control over player return to sport as this was up to the coach’s discretion.

Although the FIFA 11+ program has demonstrated its ability to reduce the number of non-contact injuries, Chapter 6 reported that in the current investigation, there were no changes in these injuries. This may have been due to the fact that the team did not participate in the conditioning program prior to the beginning of the competitive season and as it has been suggested that a period of pre-season conditioning is highly desired for team readiness, more promising results may have occurred had the team completed this pre-season training.

There were also shown to be differences in the injuries reported by male and female youth players with the former recording over twice as many injuries. These results disagree with most previous literature that states that females generally sustain more injuries than males at the youth level (Yard, et al., 2008). This may have been due to the females using the ball and training at a lower intensity than their male counterparts. Indeed the females did report a lower RPE than the males during the season. However, the characteristics of the injuries reported in Chapter 5 were similar between the genders with lower limb incidences during training session time being the most common further supporting the common injury information found in previous literature (Yard, et al., 2008) and Chapter 6.

As sub-elite and amateur teams such as those involved in this investigation often don't have access to medical assistance at all times, injury prevention is often highly desired by the coaches and players. Thus, evidence such as that demonstrated in this project offers a potential solution that may assist in preventing and rehabilitating injuries at the sub-elite and amateur level. Although sub-elite teams have certain limitations such as time restraints, programs such as those provided in this project offer an opportunity to introduce S&C exercises to those coaches and athletes who may not have much time to participate in additional training time.

Additionally, it was found that the team in Chapter 6 who performed the intervention also performed more successfully during the season winning more games, scoring more goals and finishing higher on the ladder at the end of the season than the previous year. Thus, it is suggested that not only does the soccer specific S&C program aid injury severity prevention and possible improvements in fitness, it also has a possible positive relationship with improvements in team performance during the season.

Finally, the findings of Chapters 5, 6, 7 and 8 lead to the discussion in Chapter 9 concerning issues that S&C coaches can expect to face when working with sub-elite coaches and athletes. Many potential issues arose during Chapters 5, 6, 7 and 8 with compliance and apparent lack of education of coaches and players being standout obstacles that can create problems for S&C coaches. The current investigation established that the lack of compliance is high in these sub-elite levels of competition due to numerous reasons such as general lack of interest or laziness, family or work commitments, injuries and simply not understanding the importance of such conditioning programs. S&C coaches may find that compliance issues may be the hardest problems to overcome due to essentially having to convince both the coaches and players of the importance of S&C training. Additional difficulties that can appear when working with sub-elite teams in particular, is the lack of accessibility to high-quality equipment and facilities. This can not only hinder the implementation of desired training sessions, but also affect individual athlete's risk of injuries and performance during a session. Evidently, a team's hope of improvements in physical performance can be affected before the session even begins. Furthermore, time and financial constraints at these levels of competition for both the players and coaches provide further barriers that coaches must consider when attempting to design training sessions aimed at improving fitness and game performance (Grove, Lavallee & Gordon, 1997). Coaches are encouraged to consider what constraints they and their players may face before deciding how best to implement training sessions.

Additionally, one major issue that appeared to continuously arise throughout all of the studies was that the sub-elite coaches were not considering how best to implement training sessions that were appropriate for their players. For example, as the players were at a sub-elite or amateur level, it is not suitable to train them in the same way as those at the elite level due to the differences that have been mentioned previously. Thus, a "one size fits all" approach is not recommended. However, these current studies demonstrate that unfortunately this approach is common at the sub-elite and amateur level and consequently, a need for further education at this level is required.

Finally, Chapter 9 in particular highlighted the importance of the S&C coach's relationship with both the players and sports coaches. Again, education plays a key role in developing this relationship and solidifying the need for the S&C coach in seasonal preparation in both fitness and injury prevention. In order to support this progress, it is necessary for the S&C coach to identify the characteristics of their players such as the level of competition, training age, gender and age. This will enable the S&C coach to interact with them and design training sessions appropriately for the goals that have been set.

10.5 Practical applications

The results from the current studies suggest that although there were not significant improvements in seasonal fitness in sub-elite and amateur soccer teams following the use of the soccer specific S&C program, the intervention did show it can have a positive effect on decreasing the severity of injuries. Additionally, a number of considerations the S&C coach must undertake when working with such athletes were established during the project and thus, several practical applications have been produced for both sports and S&C coaches to utilize when implementing training sessions and periodization.

1. In order to increase fitness and aid in injury prevention in sub-elite and amateur soccer players, soccer training session design should include both SSG and a soccer specific S&C program that incorporates the FIFA 11+ exercises. These sessions should also be periodised taking into account both the ball specific work and the S&C programming. This soccer specific conditioning program may also assist in offering a solution for those players who miss training or need additional support as it requires minimal equipment..
2. In order for the program to have the best chance of being successful, it is advised that it should be introduced at the beginning of the pre-season period and then continued throughout the competitive season. This duration will allow for the players to first familiarize themselves with the exercises and then improve their performance of them throughout the season. Additionally, players should be encouraged to continue the program during the off-season to maintain the level of fitness and injury prevention that was gained during the year (Grooms, et al, 2013 & Padua et al, 2012).
3. In order to limit the potential for low compliance during the implementation of a conditioning program, it is suggested that a trained professional be present during training sessions to ensure the best chance of players and coaches participating in the session appropriately.
4. The frequency at which the conditioning program is performed in amateur teams should be approximately two times per week to allow for the players to have the best opportunity of reducing the risk of injury (Barengo, 2014).

5. This investigation determined that more education is needed for both coaches and players in terms of what S&C is and why is it important. It is suggested that S&C coaches attempt to educate sub-elite and amateur coaches and players on the importance of physical conditioning and the need for a S&C coach within staff.
6. The findings from this project also demonstrate the need for sport and S&C coaches to consider the differences in players that need to be taken into account such as gender, age and competitive level. For example, due to the anatomical differences that exist between male and females, especially at the youth level, coaches must consider implementing different coaching techniques, especially in terms of power training, to ensure that training is specific to the players' abilities and bodies. Additionally, coaches must consider the skill level of the players when designing and implementing training sessions. Those players who do not possess the ability to perform SSG or skills at a high level, will require additional conditioning training to improve fitness and cannot rely solely on SSG for fitness.

10.6 Recommendations for Future Research

Suggestions for potential future research based on the current investigations findings include:

1. Seasonal variations in fitness in Australian soccer players with a high compliance to S&C sessions

   Chapters 3, 5 and 6 demonstrated that there were no seasonal changes in fitness throughout the course of the seasons. Additionally, there was a lack of compliance to training sessions from players within the tropics of Australia. Subsequently, Chapter 9 discussed these compliance problems in detail and offered some possible solutions. Some potential reasons for lacks of compliance were due to the time constraints and lack of education of amateur players. Thus, it could be suggested that players at a higher level of professionalism may respond differently in terms of attendance. Therefore, it would be interesting to investigate and compare the seasonal variations in fitness in soccer players of differing levels within Australia. For example, research could be completed on further sub-elite and elite teams from non-tropical environments to allow for a comparison to be completed with teams from the tropics and establish if there is an environmental factor that influences performance. Additionally, this could determine if there are differences between the two levels of competition in terms of seasonal fitness changes.

2. Training session structure and use of SSG in amateur players

   Within the current investigation, the sports coaches had a high level of influence in the training session structure design and as such, there was minimal time allocated to S&C training throughout all Chapters. Consequently, part of the reason as to why there were no improvements in seasonal fitness of the players was due to the high use of SSG for training and a lack of time allocated to S&C. Although this method has proven to be successfully in Europe and Northern America, the Australian teams within this investigation have shown that the way in which players respond to SSG training may differ between countries. As demonstrated particularly in Chapters 5 and 6, this type of training may not necessarily be the best choice if improving and maintaining fitness throughout a season is the intention of the coaches and players, particularly in Australia. Thus, it is recommended that if there was an increase in the S&C time during each training session, there may have been more successful results in terms of fitness performance. It is therefore suggested that more research should be completed on a team where additional S&C training to that shown within this project is implemented.

   Furthermore, it is suggested that research be conducted on the way in which SSG training can be trained without hindering player fitness improvements throughout the season within Australia.

3. Injuries in Australian soccer players

   Although there has been previous research conducted on injuries in soccer from Europe and North America, there are limited studies on those of players within Australia. Chapter 5, 6 and 8 demonstrated the large impact injuries can have on the seasonal fitness in Australian soccer players and thus, there is a need for more knowledge on how these injuries occur and how best to prevent them, particularly in those sub-elite players that have limited time to train and often miss out on conditioning.

4. Education in amateur coaches and players

The current research demonstrated the gaps in education in both coaches and players at the sub-elite and amateur levels. In particular, there is a lack of knowledge on appropriate recovery and rehabilitation protocols for players and how a high use of SSG can potentially cause a negative response in fitness throughout a season. It would therefore be beneficial for a research project to investigate whether providing education to coaches and players on the aforementioned procedural issues may illicit greater improvements in seasonal fitness and aid in more successful injury prevention.

10.7 Conclusions

The aim of this project was to investigate the seasonal variations in fitness in sub-elite and amateur soccer players at the youth and adult level within Australia. Additionally, a secondary objective of the project was to examine the effects of implementing a soccer specific S&C program on seasonal fitness, training/game attendance and injuries of players. Overall, there were minimal improvements in seasonal fitness found in all sub-elite teams during the observational season due to a high use of SSG training. Although there were minimal significant improvements in fitness during the season following a conditioning intervention reported during the three presented studies, there was a decrease in the severity and risk of injuries. Additionally, it has been demonstrated that there are a number of considerations a S&C coach must undertake if they are to work successfully with both amateur coaches and players. Overall, the summaries of the findings of this project are as follows:

- There appears to be minimal significant improvements in seasonal fitness in sub-elite and amateur Australian soccer players both with and without using SSG and the intervention of a soccer specific S&C program;
- The implementation of a soccer specific S&C program assists in reducing injury risk and severity should the coaches and players have a high level of compliance;
- There is a need for education regarding periodization, SSG use and injury prevention and rehabilitation in both sub-elite and amateur Australian coaches and players;

- S&C coaches must undertake a number of considerations when working with sub-elite and amateur coaches and players including their existing S&C knowledge, training education and the time and financial restraints they may already be facing.

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12: Appendix

12.1- Conference proceedings

Hervert, S.R., & Deakin, G.B. (2014). A comparison of seasonal fitness of female adolescent netball and soccer players. *Journal of Australian Strength and Conditioning, 22*(5), 116-119.

Introduction

Two sports commonly played in Australia by adolescent females are soccer and netball. Previous research has identified that speed, agility and repeatedly executed high-intensity actions (Little & Williams, 2005) as well as strength and power (Wisløff, Helgerud & Hoff, 1998) and aerobic endurance (Castagna, Impellizzeri, Chamari, Carlomagno & Rampinini, 2006) are all important determinants of successful soccer performance. In comparison, netball requires slightly different fitness attributes including a high degree of strength/power, flexibility and speed (McManus, Stevenson & Finch, 2006). Although the two sports differ in regards to their physiological requirements, both are regarded as highly skilled games (McManus, Stevenson & Finch, 2006) that require athletes to be at their physical peak to perform well.

It is known that to be successful at a given sport such as soccer and netball, an athlete must acquire and maintain the adequate skills and fitness levels required (McManus, Stevenson & Finch, 2006). Fitness is usually gained through training and game time and some athletes such as elite soccer players can spend in excessive of fourteen hours a week focusing on such tasks (Cometti, Maffuletti, Pousson, Chatard & Maffulli, 2000). However, adolescent athletes such as those participating in regional academy teams, train considerably less than their elite and adult counterparts due to restraints such as time, affordability and other commitments (Cometti, Maffuletti, Pousson, Chatard & Maffulli, 2000). Due to this difference in training and game time, adolescent athletes are less exposed to the opportunities to develop and maintain their fitness required for the competitive season. This scenario was highlighted in a recent study conducted on the seasonal fitness in amateur female soccer academy players that showed that due to a lack of conditioning emphasis during training sessions and a high reliance on skill development, a plateau in functional ability and fitness occurred during the season (Hervert & Deakin, 2013).

Prior to the abovementioned study, there was very limited research on the changes in fitness during a season in amateur female soccer players let alone adolescent females, with the majority of research conducted to date focused on the seasonal variations in fitness of elite male soccer players. Additionally, although there have been previous studies that have investigated the injuries sustained by young female soccer players, they have been in respect to injuries registered specifically during a brief and highly competitive period of time such as a tournament (Söderman, Adolphson, Lorentzon & Alfredson, 2001), with little focus on the injuries sustained throughout an entire season. Netball, particularly at the adolescent level, has also received little attention with the majority of research focusing on elite athletes (McManus, Stevenson & Finch, 2006). In light of the limited research conducted on female adolescent soccer and netball players, it is not known if there are any commonalities between the two sports in terms of seasonal fitness trends or injuries and if these fitness trends or injuries are related to the players' age or the sports themselves. Therefore, the aim of the current study was to compare the competitive seasonal fitness of adolescent soccer and netball academy teams and determine if injuries sustained throughout the season are sport specific or is there an age related factor that goes across sports.

Methods

Twelve netball players (age 15.1±1.0 years, height 169±5cm, body mass 61.99±8.6kg) and eleven soccer players (age 15.5±0.67 years, height 163±5cm, body mass 54.95±5.2kg) from local amateur academy teams volunteered to take part in the study. Both teams took part in their respective 2013 local regional competitions from March to September for soccer and April to August for Netball. All procedures were approved by the Institutional ethics committee prior to the commencement of the study and each player signed an informed consent.

Although the two teams completed the testing sessions at separate times, both followed the same protocol. Players attended a testing session at both the beginning and end of the competitive season. A 10 minute standardised warm up was completed before players performed basic anthropometry tests (height, weight and body fat percentage), flexibility test (sit and reach test), lower body power test (vertical jump), an agility test (505 agility), and two functional tests (shoulder flexibility and functional squat).

Following the necessary anthropometric test measurements and warm up, players performed a sit and reach test to assess for hamstring, trunk and hip joint flexibility. To assess for lower body power, a Swift Performance Yardstick was used to measure the players vertical jump height. Players were asked to complete a jump at maximal height using a countermovement jump method and the height reached was measured to the nearest centimetre. Players then completed a 505 agility test. An arm over-under flexibility test was used to assess for shoulder flexibility. The distance between the hands were deemed to be of a positive or negative value and measured to the nearest centimetre. The functional squat test has previously been described as the ability to perform a full range squat whilst holding a bar overhead at an arms-length (Cook, 1998). Players were awarded a score between 0-3 depending on who well they performed the squat (Cook, 1998). Both the under over and functional squat tests were analysed by testers who were experienced with functional movement testing. Players were instructed to complete all flexibility, power, agility and functional tests for a total of three trials with the best result recorded for analysis. Speed and aerobic capacity were not tested due to the different requirements of these variables within soccer and netball.

In addition to the fitness data, injury data on both teams was also collected by coaches and investigators throughout the season. An injury was defined as one that occurred during the course of the season and eventuated in the player not being able to complete training or a game at 100% capacity (Stevenson, et al., 2004). Information that was collected on injuries included the position of the player injured, the time and how the injury occurred, site and type of injury, as well as the severity of the injury. Due to the difference in length of season between the two sports, the actual number of exposure hours was therefore different with soccer reporting 1,694 hours while netball had 1,260 hours.

Consequently, the injury data is expressed as the number of injuries per 1000 sustained in the respective seasons for comparison purposes.

All data is expressed as mean ± standard deviation. Two way (group x time) repeated measures ANOVA tests were used to determine if there were any significant differences between the teams and from pre- and post-season for each performance variable. The alpha level was set at 0.05.

Results

There was limited change throughout the seasons for the fitness variables tested on both the netball and soccer teams (Table 1). The soccer team reported a significant change in vertical jump with a deterioration of approximately 20% from pre to post season while the netball team showed no change. Similarly, the soccer team significantly deteriorated in their 505 agility and left handed over under performances whereas their netball counterparts showed no change throughout the season.

Table 1. Anthropometric and physiological/functional performance characteristics of the female netball and soccer players from pre to post season.

	Netball		Soccer	
	Preseason	Postseason	Preseason	Postseason
Height (m)	1.7±0.0	1.7±0.0	1.6±0.0	1.6±0.0
Weight (kg)	62.0±8.5	63.3±8.4	55.0±5.2	56.6±6.4
Body Fat Percentage(%)	26.1±4.5	25.6±4.6	23.5±3.8	24.2±3.3
Sit and Reach (cm)	9.7±6.9	10.4±6.2	8.1±3.7	8.6±4.6
Vertical Jump (cm)	39.8±9.0	40.8±3.8	46.3±11.0	36.9±3.2*
Right Foot 505 Agility (s)	2.62±0.15	2.61±0.11	2.51±0.11	2.62±0.13*
Right Arm Over Under (cm)	11.6±6.5	12.0±6.0	7.8±4.2	10.3±5.3
Left Arm Over Under (cm)	9.5±7.2	9.7±7.7	5.6±3.4	6.4±4.2*
Functional Squat	1.8±0.6	1.8±0.6	2.0±0.5	1.8±0.8

*indicates significant difference from pre-season trial (P<0.05)

Table 2 outlines the injuries sustained by the netball and soccer teams throughout the season. Both teams reported the same number of injuries over the course of the season, with 9 in total. Both teams also suffered considerably more injuries during games than under training circumstances and the majority of injuries were located on the legs. The netball team reported that players in attacking and centre/midfield positions accounted for nearly all injuries during the season (89%) whereas players in defensive positions were more prone to injuries in the soccer team (67%). The netball team recorded that over 33% of the injuries were deemed to be 'not game or training related' compared to soccer's 11%. The soccer team reported 'ligament damage' whilst the netball team reported 'bone/joint' to be the cause of over 50% of injuries. Cause of injury was assorted among the netball injuries with 'movement', 'contact' and 'overuse' accounting for majority of the injuries. The soccer team however, stated that two thirds of injuries were due to 'contact with an opposition player'. Injury severity also differed between the two sports with netball reporting approximately half of the injuries as either 'minor' or 'severe' whilst the soccer team injuries were either 'mild' or 'severe'.

Table 2. Description of netball and soccer player injuries over the course of the 2013 competitive season

Player position	Attacking	Midfield/centre	Defence
Netball	3.17	3.17	0.79
Soccer	1.77	0	3.54
Time of Injury	Game	Training	Not training/game related
Netball	4.76	0	2.38
Soccer	3.54	3.54	0.59

Injury occurrence	First half	Second Half	
Netball	2.38	2.38	
Soccer	0.59	2.95	
Site of Injury	Arms	Torso	Legs
Netball	0.79	1.58	5.56
Soccer	1.18	0.59	3.54
Injury Type	Bruise/Muscle	Ligament	Bone/Joint
Netball	3.17	0	3.97
Soccer	1.77	2.95	0.59
How did injury occur	Movement (e.g. sprinting)	Contact (e.g. opposition)	Overuse
Netball	3.17	3.97	3.17
Soccer	1.18	3.54	0.59
Injury Severity	Minor	Mild/Moderate	Severe
Netball	3.17	0.79	3.17
Soccer	0.59	2.95	1.77

*Data expressed as per 1000 exposure hours

Discussion

The aim of the current study was to compare the competitive seasonal fitness of adolescent soccer and netball academy teams and determine if injuries sustained throughout the season were sport specific or if there was an age related factor that went across sports. The major finding of the current study was that neither team showed any fitness improvements over their respective seasons. The soccer team showed significant decrements in the vertical jump, 505 agility and over under performances, whilst the netball team had no significant changes in any of the fitness variables. The injury data indicated that there were some similarities between the two sports in respect of injury patterns with the majority of injuries suffered during games and to the legs. However, there were differences between the two sports in the player positions that were most injured, the cause, the type and the severity of the injury.

The lack of improvement in seasonal fitness in the teams may be related to the amount of specific conditioning training undertaken on a weekly basis. Although no training data was specifically recorded for this study, it is known by the authors from conversations with coaching staff, that no specific conditioning training was used to enhance player’s fitness within training sessions for the soccer team over the course of the season. All training focused on ball skill and tactical development only. The deterioration in jumping power and agility tends to supports this finding as too previous soccer team research using the same training model (Hervert & Deakin, 2013). Given that both of these fitness attributes are important to soccer play it would be advisable to ensure that at least pre-season fitness levels are maintained over the season. The netball team on the other hand did incorporate specific conditioning drills into the players’ weekly training routine as advised to the authors by coaching staff. Whilst these sessions may not have been sufficient to improve fitness over the season, the sessions did allow the players to maintain their fitness.

Whilst the injury data showed that there were some similarities between the two sports for the time of injury occurrence (mostly games) and location of injuries (legs), for all other injury data the sports were different. This suggests that the injuries sustained by players were not specifically age related. The similarity in functional movement between the two teams also supports this. Given that the players of both teams were of similar age (~15 years), the difference in injury patterns between the teams appears to be related to how the sport is played. The player position data confirms this, as the soccer team suffered the majority of its injuries to defensive players whilst the netball team to attacking players. An interesting finding of the study was pattern of injury. Soccer is classified as a contact sport and as such one would expect injuries to occur during contact between opposing players whilst contesting ball possession. Indeed, within the current study two thirds of injuries sustained during the season were by means of contact with an opposition player. However, this is in contrast to previous research that has found that more injuries occur due to non-body contact activities like running or turning as opposed to body contact (Hawkins, Hulse & Wilkson, 2001).

Comparatively, with netball being a non contact sport, injuries such as stress fractures occurring from repeated impacts with hard surfaces during landing and hopping are common within the sport (Stevenson, et al., 2004). Whilst overuse injuries did account for a third of the netball injuries in the current study, contact with an object such as the ground/opposition and running or turning movements accounted for the majority of injuries.

The injury data for both teams did highlight two issues of concern. First, the number of injuries experienced by the netball players outside of the academy team and second, the type and severity of the injuries, particularly for the soccer team. A difference between the two academy teams in terms of organization is that the soccer academy players only play for their designated academy team whereas the netball players also play and train with their local clubs when not attending academy training and games. This scenario may be over exposing the netball players to too much activity, thus not allowing sufficient recovery between training/games. The fact that approximately a third of all injuries in the season are overuse does support this point. Maybe necessary to monitor and limit netball academy players to training and playing for the academy only if this injury pattern is commonly occurring. In respect of the soccer injuries, a factor that may be contributing to the number and severity of the injuries is the lack of sport specific conditioning particularly given that the team experienced deteriorations in seasonal power and agility. Previous research has shown that the incorporation of an appropriate injury prevention conditioning program can reduce soccer player injuries (Jones & Drust, 2007).

In conclusion, there are differences between adolescent soccer and netball academy teams in respect of seasonal fitness which may be related to the model of conditioning training utilized. The results also indicated that injuries sustained throughout the season by the respective academy players were sport specific and not age related.

Practical Applications

The findings of this study indicated that in order to maintain seasonal fitness attributes for a sport, whether it be soccer or netball, one must incorporate specific conditioning training to the weekly training regime. In addition, to aid in reducing the number and severity of injuries sustained in adolescent sports like soccer and netball, then the use of proven injury prevention programs such as FIFA 11+ should be implemented into the training sessions both during preseason and the competitive season (Jonest & Drust, 2007).

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12.2 Injury Data Form

INJURY RECORD FORM

Player Characteristics

Player code: ___________________________________

Date of injury: _________________________________

Injury Definition

An injury is defined as:

(a) An incident that requires an official (coach, trainer, referee or medical personnel) to visit a player on the field during a game or training

(b) An incident that requires a player to receive first aid/medical treatment

(c) An incident that prevents a player from continuing in a game or training

FOR EACH SECTION PLEASE CIRCLE THE RESPECTIVE ANSWER:

Injury Conditions

1. Player position:

Goalkeeper / defender / fullback / mid-field / wide mid-field / forwards

2. When did the injury occur?

Training Game

Other____

3. Time injury occurred:

Game: - warm-up / first half / second half / cool-down

- beginning of half / middle of half/ end of half

Training: warm-up / beginning / middle / end / cool-down

4. Environmental conditions at the time of injury: Fine Wet

5. Ground conditions at time of injury: Dry Wet

Injury Characteristics

6. Where on the body did the injury occur?

Head – nose / eye / ear / mouth / face / neck / top of head / back of head

Arms – shoulder / upper arm (biceps / triceps) / elbow / wrist / hand / finger

Torso – chest / abdomen / upper back / lower back

Legs – hip / buttocks / groin / quadriceps / hamstring / knee / calf / shin / ankle / foot / toe

7. Which side of the body?

Left Right Bilateral N/A

8. What kind of injury?

Bone (fracture) / muscle / ligament / abrasion / bruise / dislocation / concussion

If other, please provide details:

____

9. How did the injury occur?

Running / jumping / side stepping / falling / slipping / kicking

Contact with object (goal post / fence / ground)

Contact with person (opposition player / own player / referee / official)

Overuse

Cause unknown

10. If the contact was with another player (opposition or own), was it the result of:

Tackling / being tackled / collision

11. Did the injury require first aid or medical treatment? Yes No

12. Injury severity:

Minor – player able to stay on field and continue game and training
Mild – player unable to continue playing current game or training but able to participate in next game or training session
Moderate – player unable to play next game but still able to train
Severe – player unable to play games or participate in training

13. Time lost:

Training time lost (number of sessions) ____________
Playing time lost (number of games) ______________

Comments ____

____

12.3- Permission for Print

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has been removed

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12.4- Ethics Approval

This administrative form has been removed

This administrative form has been removed