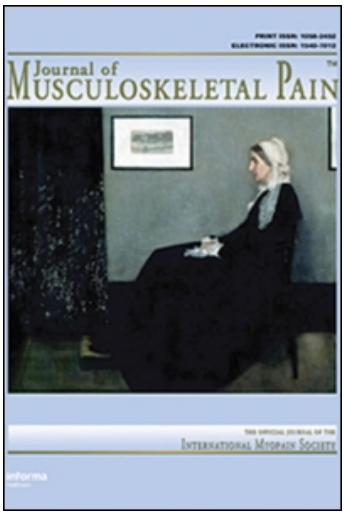

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Military Training and Musculoskeletal Disorders

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ABSTRACT. Objectives: This study examined the extent to which musculoskeletal disorders [MSD] affect military populations, as well as intrinsic and extrinsic factors associated with MSD and the relative contribution of training, sports, and manual handling. A search of published literature was conducted using PubMed-listed articles published up to February 2006.

Findings: Although physical conditioning represents an important facet of military preparedness, up to half of all recruits may suffer an injury during their basic military training. Musculoskeletal disorders are a common occurrence for soldiers and represent an important source of morbidity for the military as a whole. Intrinsic risk factors linked to military training injuries include a diverse range of inherent variables such as the level of prior physical conditioning, psychological make up, age, height, weight, and gender. Extrinsic risk factors for military MSD include training surface, exercise when fatigued, progressive training in place of cyclical training, and the type of footwear usually worn. Other military-specific variables may also include drill methods, the arrangement of platoons, training technique, and the actual training distance.

Conclusions: Overall, this review suggests that MSD are a common occurrence for military personnel and represent an important source of morbidity for the military as a whole. In meeting this problem, there is clearly an urgent need to target effective preventive measures, especially those involving military-specific training and sports activities. doi:10.1300/J094v15n02_06

KEYWORDS. Military, musculoskeletal disorders, training, prevention, physiotherapy

INTRODUCTION

Musculoskeletal disorders [MSD] represent a major issue in the military setting. Military personnel are exposed to a range of physical training, sporting, work and recreational activities that may result in MSD. Physical conditioning has traditionally represented an important

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facet of military training and readiness. Exposure to training loads of sufficient intensity, duration, and frequency will produce quantifiable and specific training effects, which are generally associated with functional improvements for which the training has been undertaken (1). Muskuloskeletal disorders in military personnel contribute to substantial losses of time from work and training, as well as reductions in overall military readiness. The resulting morbidity represents a substantial cost to the community (2-6), particularly when extrapolated from that in the civilian workforce (7). For these reasons, prevention of MSD in the military setting should be paramount (5,8).

Military training provides a model for studying the effect of implementing basic scientific data in a relatively homogeneous sub-set of the general population, where policy decisions and protocols can be readily and consistently implemented and outcomes can be easily measured. In this review, we examine the extent to which MSD affects military populations, as well as intrinsic and extrinsic factors associated with MSD and the relative contribution of training, sports, and manual handling. A better understanding of factors related to MSD will assist in designing improved prevention programs in both military and civilian populations. To facilitate the review, a search of published literature was conducted using PubMed up to February 2006. The medical subject headings "musculoskeletal" and "military" were used to identify articles relating to military training, sports, and MSD. Reference lists were also examined to locate additional articles.

Extent of Musculoskeletal Disorders in Military Populations

Contemporary military research in the field of MSD has mainly focused on groups of military recruits undergoing basic training. A systematic review found that MSD rates during military training range from six to 12 per 100 male recruits per month, during basic training, and up to 30 per 100 per month in Naval Special Warfare training (9). Some studies have suggested that as many as 50 percent of recruits can be expected to suffer an injury during their basic military training (3,8). Linenger (9) calculated an incidence profile of 19.9 per 100 recruit-months at risk for a group of United States Marine recruits during basic training, using MSD data derived from military sports medicine and podiatry clinics. A number of studies have attempted to quantify the amount of training time lost as a result of MSD and other training injuries (3,6,11,12). Other studies have examined the rate of training failures (13).

There have also been some investigations which looked at MSD among more seasoned military personnel. Neath and Quail (14) found that MSD were more common in military personnel than civilians. A study of nearly 5,000 referrals for physiotherapy in the Australian Army found a prevalence of MSD to be approximately 19 percent, per year. This yielded the equivalent of only 1.6 cases per 100 person-months at risk (15). The relatively lower rates of injury established during the latter investigation may relate to specific selection effects, in that the majority of their subjects would have been experienced soldiers participating in activities to which most of them would have been accustomed, rather than new recruits who were undertaking arduous activities for the first time. The figures reported by Gruhn et al. (15) are lower than injury data derived from other military and civilian athlete populations (8,16). For example, Kolt and Kirkby (17) reported injury rates of 1.98 injuries per gymnast, per year of participation, during a study of competitive gymnasts, which is around 10 times higher than that reported for the military population (15). The authors concluded that injury levels in gymnastics were substantially higher than in most other sports, including those that had traditionally been viewed as high-risk activities, such as football.

Bodily Location of Musculoskeletal Disorders

Although the exact location of MSD among soldiers may vary, body sites typically referred to physiotherapists often involve the knee joint, lumbar spine, ankle joints, and shoulder joints

(15). In this regard, Pollock et al. (4) suggested that between 20 to 40 percent of military training injuries involved the knee joint. According to these authors, most knee injuries were reported to have occurred during military training activities, which also accounted for the greatest relative portions of lumbar spinal problems and ankle problems treated. Interestingly, military training accounted for a relatively smaller proportion of injuries to the shoulder (15). The shoulder was the site more often affected by football and other causes (16), even amongst soldiers (15). In a study of over 15,000 hospitalized military personnel in the United States over the period 1989 to 1996, the most common location for MSD was the back, which was found to have the greatest five-year cumulative risk of disability (18). It is well known that aircrew in particular are affected by MSD, particularly that which involves the spine (19,20).

Intrinsic and Extrinsic Risk Factors for Musculoskeletal Disorders

It is important to understand the factors which may be associated with MSD so that prevention and management strategies can be most effectively targeted. A number of risk factors for MSD have been identified for military populations in this regard. Risk factors for MSD can be classified as being either intrinsic or extrinsic (21). Lysens et al. (21) described intrinsic factors as representing the physical and psychological characteristics of the participant. Extrinsic factors were defined in terms of exposure to the sporting activity, the manner in which preparation for the activity is undertaken, the equipment used, and the prevailing environmental conditions. Intrinsic and extrinsic factors have been summarized in Table 1.

Intrinsic factors which have been linked to military training injuries include the level of prior physical conditioning (2,5,22-24), the soldier's psychological make up (2,22), foot hyperpronation (23,25-29), female gender (23,30,31), tibial bone width (32), and cigarette smoking (5). Other authors have also proposed links between injury and a diversity of intrinsic factors, such as bone mineral density (32-34), age (23,24,34,35), height (23,30), weight/body mass index (36), and specific alignment characteristics of body segments (13). Biomechanical factors have particularly been associated with MSD of the lower back (37).

Extrinsic factors associated with MSD-related injuries have previously included training surface (22,23,26), exercise when fatigued (38), progressive training in favor of cyclical training (35), and the type of footwear worn (26,30). Ross (31) suggested that drill methods, the arrangement of platoons, training technique, and the training distance represent potentially important extrinsic risk factors for injuries in the military. Winter training has also been associated with injury during basic training in the Royal Australian Air Force (36). Running has been associated with lower limb MSD when compared to other training activities (39). Interestingly, changes to army recruit's physical training programs in Australia, such as the reduction of test-run distances from 5.0 km to 2.4 km, appear to have resulted in a 41 percent reduction in medical discharges, as well as a considerable reduction in the costs associated with medical investigations (40). This result was similar to previous studies involving reduced running distance (41). Time pressure has been particularly associated with MSD of both the lower back and upper extremities (37,42).

Despite this fact, studies of predisposing factors for training-related injuries remain complex and multi-faceted (16). Many investigations, particularly cross-sectional studies, have had difficulty establishing associations between possible risk factors and injuries, even though an association between two variables does not necessarily infer causation (8). Whether it concerns military or civilian athletes, opinions based on contemporary knowledge of MSD risk factors tend to remain divided, based partly on scientific, anecdotal, and circumstantial evidence. Pioneering epidemiological research into sports-related injuries by means of physiotherapy treatment records was first conducted by Jull and Cupit (43,44) during the early 1980s. This was followed by Gruhn et al. (15), who pioneered the use of physiother-

TABLE 1. Intrinsic and Extrinsic Factors Associated with Musculoskeletal Disorders During Military Training

Intrinsic Factors	Extrinsic Factors
• Level of prior physical conditioning • Psychological make up • Foot hyperpronation • Female gender • Tibial bone width • Cigarette smoking • Bone mineral density • Age, height, and weight [BMI] • Specific alignment characteristics of body segments • Previous history of MSD	• Training surface • Exercise when fatigued • Progressive training in favor of cyclical training • Footwear • Drill methods • Arrangement of platoons • Training technique • Training distance • Winter training • Time pressure

BMI = body mass index, MSD = musculoskeletal disorders

apy records in the examination of injuries of presenting military personnel.

Demography and Musculoskeletal Disorders

The predominance of younger ages and male gender in military populations most likely reflects the general age, gender, and rank characteristics of the wider military population. This in turn, might further account for the relative preponderance of lower ranking, male, enlisted personnel presenting for physiotherapy treatment (15). In general terms, rank and age are likely to be related in a military population, given the length of service requirements for promotion in most military organizations. In hospitalized military patients, older age groups with MSD were over-represented (18). There have been few studies comparing services, although it is known that navy (45) and air force (20) personnel are probably afflicted with MSD as much as any other personnel.

Variations have been found for injury profiles between males and females. In the study by Gruhn et al. (15), there were disproportionately more female admissions as a result of largely undiagnosed, insidious onset-type injuries. There were also considerably fewer female referrals than expected relating to joint pathology arising from participation in football or general sporting activities. There were also substantial variations in the anatomical distribution of injuries between male and female patients, with a relatively greater proportion of females presenting with injury to their lumbar spine.

Gender differences in injury profiles may reflect differences in both participation levels as well as the nature of physical activity undertaken by females in the military. For example, a prospective study by Strowbridge (46) found no gender differences in injuries caused by sport or road-traffic accidents, but that military training, work, and recreation were more likely to be the main cause of injury to females. Such hypotheses are supported by research demonstrating equivalent injury risks in male and female athletes who undertake sports, which place similar demands on both genders. On the other hand, dissimilar injury profiles have been established in sports, which place different demands on males and females (16). It is important that females who have sustained an injury take steps to prevent it from recurring and continue to seek early referral for treatment and rehabilitation (47).

Training, Sports, and Musculoskeletal Disorders

While studies of civilian and military populations have tended to link participation in sports with an increased MSD risk (8,10), recent military investigations have raised conflicting evidence for the contribution of military training to the promotion of physical fitness. This suggests that the kind of training undertaken and the processes underlying the

delivery of training may be key factors in MSD pathogenesis. Research from a National Guard's physical training unit, for example, found that physical conditioning made no difference in scores on physical fitness testing (48). By contrast, an alternative study (49) suggested that senior military officers maintained a high aerobic activity level and were generally normotensive, non-obese, and at low risk for the development of cardiovascular diseases. In another study (50), female military officers appeared to be fitter and have lower cardiovascular risk factors than their female civilian counterparts. However, the potential for selection effects and positive bias must be taken into account when considering research based on military populations, as military recruitment and retention practices are generally designed to limit or prevent the selection of unfit individuals.

The study by Gruhn et al. (15), which found that more than half of all physiotherapy admissions are related to military training, football, or other sports, suggests that these areas should continue to be targeted for prevention. Of the combined football and other sport injury admissions, female personnel had significantly fewer physiotherapy referrals than expected, which may simply reflect reduced female participation in football and certain other sports. Gruhn et al. (15) also showed that the majority of football and general sports-related injuries were referred between April and September, the traditional "football season" in Australia. This period was additionally identified as the peak time for lower limb injuries. The remaining injury categories were distributed roughly equally throughout the year, as participation in military training, military duties, and other sports generally continues irrespective of season. Most football-related injuries affected the lower limbs, particularly the knee and ankle joints, which is consistent with data from studies of civilian football players (16). Injury profiles reported by Seward et al. (51), for example, suggested a relatively high frequency of lower limb injuries in elite-level footballers, particularly Australian Rules football players.

Manual Handling and Musculoskeletal Disorders

In their study of MSD among military personnel referred for physiotherapy, Gruhn et al. (15) demonstrated that there were higher-than-expected frequencies of manual handling MSD seen in association with the lumbar spine. Manual handling injuries refer to a variety of disorders sustained when undertaking manual physical activities, such as lifting or moving heavy things. These incidences accounted for more than four-fifths of all manual handling related referrals, and nearly one-third of referrals overall. Such findings likely reflect the predominantly load-bearing nature of military duty, placing both the lower extremities and lumbar spine at increased injury risk (9).

Diagnosis and Reporting of Musculoskeletal Disorder

A high proportion of physiotherapy referrals for MSD appear to involve undiagnosed conditions (15). This phenomenon may, in part, reflect intrinsic difficulties in establishing a definitive diagnosis where musculoskeletal conditions are concerned, particularly those injuries involving the lumbar spine and knee joints. Aside from the military, relatively high referral levels without definitive diagnosis have also been reported in civilian private practice (52). This has been shown to occur where specific prescriptions by referring general practitioners and medical specialists occurred in less than 25 percent of cases, and treatment at the therapist's discretion was suggested in more than half of the referrals for physiotherapy (52).

Diagnosis of MSD can also be deferred by the delays in presentation and treatment. The timing of MSD treatment in the military may reflect certain injury-related factors. In the study by Gruhn et al. (15), for example, military personnel with football and sports-related MSD were referred earlier for physiotherapy treatment. This may reflect the greater motivation of personnel participating in football and other sports to return to their peak levels of fitness and

performance as soon as possible. Personnel with ankle injuries were referred earlier for physiotherapy treatment than those with injuries to the knee, lumbar spine, and shoulder. As such, it may be that the clearly identifiable nature of ankle injuries, combined with the functional disability it usually causes, made early referral more likely on the part of both the personnel who suffered and the medical officers who referred them. For similar reasons, joint and soft tissue injuries may have been referred more rapidly than other types of pathology.

Soft tissue injuries and conditions without definitive diagnoses have also been shown to receive fewer consecutive treatments than joint, bone, and other types of pathology among military personnel (15). Surprisingly, the knees, ankles, and shoulders of soldiers may also receive relatively greater median numbers of physiotherapy treatment than injured lumbar spines in the military (15). This finding appears to contradict findings based on civilian physiotherapy practice, where lumbar pain was shown to be the most resistant to treatment, compared with other types and other sites of injury (53). Soldiers with unresolved lumbar pain should be referred to medical practitioners as soon as possible for specialist review and restricted duties, so that treatment and rehabilitation can be initiated earlier to prevent the development of long-term problems.

Although information systems recording MSD are improving in the military setting, those programming information systems need to consider delays in diagnosis as well as the evolution of diagnoses. Previous research has found that the use of initial diagnosis during official reporting of workers' compensation claims for back injuries may result in considerable misclassification (54). The ability to provide a discharge diagnosis, once further medical investigations and physiotherapy assessment and treatment had been completed, would most likely reduce the proportion of undiagnosed conditions. A review by Kenton et al. (10) found limitations in the capacity of military outpatient surveillance systems to capture all the data required to appropriately identify risk factors for MSD and further develop preventive measures for MSD in military personnel. The use of specific injury classification systems, such as the Orchard Sports Injury Classification System (55), may enable more precise recording and consistent categorization of injuries, such as demonstrated by Gruhn et al. (15). Current recommendations for the prevention of MSD in military personnel are given in Table 2.

CONCLUSION

This review has highlighted the fact that MSD are a common occurrence for military personnel and represent an important source of morbidity for the military as a whole. Although the distribution of MSD within military populations is generally consistent with sports-specific investigations of civilians, there appears to be some variability in the pattern of MSD reported as a result of military training. In meeting this problem, there is clearly an urgent need to target effective preventive measures, especially those involving military-specific training and sports activities.

TABLE 2. Recommendations for the Prevention of Musculoskeletal Disorders Among Military Personnel

- Specialized and individualized physical training rather than general sporting activities
- Maintenance of physical fitness
- Appropriate biomechanical conditions and correction as required
- Strict adherence to manual handling guidelines
- Smoking cessation programs
- Education concerning early warning signs of MSD
- Early presentation for investigation and management of MSD
- Appropriate allowance of time for recovery and rehabilitation

MSD = musculoskeletal disorders

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