Review of physiotherapy records to characterise musculoskeletal injury in Australian soldiers in the 16th Air Defence Regiment

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Abstract

Background: There is scant information on the types of musculoskeletal injuries, their causes and injury patterns that are sustained by Australian garrison soldiers (a permanent military post or place where troops are stationed). Rigorous physical training, manually emplacing weapon systems and daily military duties carried out by soldiers of the 16th Air Defence Regiment reflect the types of injuries observed in this study. It defines the injury patterns for trained soldiers and addresses those aspects of injury and mechanism of injury, forming the basis for further research targetted at injury prevention.

Purpose: To identify the predominant musculoskeletal injuries sustained by soldiers of the 16th Air Defence Regiment and to explore the relationship between the type of injury and subunit as well as the relationship between type of injury and cause. This is important so that remedial measures can be engaged in an attempt to reduce the incidence of musculoskeletal injury to Australian soldiers, to maintain the regimental fighting strength and deployable status and to reduce the financial burden of rehabilitation and compensation borne by the Australian Defence Force and the Federal Government.

Materials and Methods: All patients were trained serving soldiers of the 16th Air Defence Regiment and were referred by the Medical Officer for physiotherapy treatment. On conclusion of a course of treatment, a physiotherapy patient discharge summary (PM 528) was written and it is from these summaries that the demographic data for this study was extracted, which included the type of musculoskeletal injury (diagnosis), cause of that injury and the subunit that the soldier belonged to in the 16th Air Defence Regiment during the years 2008 to 2010.

Tests of significance based on the chi-square test statistic were carried out at the 0.05 significance level using Minitab 16 statistical software. When the chi-square test of independence was significant, then the source of the dependence was investigated by analysis of standardised residuals for each cell.

Results: Five predominant types or areas of injury sustained by Australian soldiers of the 16th Air Defence Regiment were identified to be neck, low back, ankle, patella and knee ligament. The frequency of low back injuries was found to be significantly higher than the other types of injury (chi-square goodness of fit test, $p < 0.001$, then analysis of standardised residuals with Bonferroni adjustment).

There was insufficient evidence of a relationship between type of injury and subunit (chi-square test of independence, $p = 0.33$).

Five predominant causes of musculoskeletal injury were identified to be biomechanical, work, running, sports and physical training.

Evidence of a relationship between type of injury and cause was found to be statistically significant (chi-square test of independence, $p < 0.001$) in the cause 'sports', which is associated with a relatively higher frequency of ankle inversion injuries, and 'running', which is associated with a relatively higher frequency of patella-femoral joint injuries ($p < 0.002$).

Conclusion: This is the first full review of data on musculoskeletal injuries sustained by Australian soldiers of the 16th Air Defence Regiment. Types of musculoskeletal injuries and causes were analysed and patterns of injury were identified. Measures can now be drawn up with the aim of injury prevention.

Introduction

The 16th Air Defence Regiment (16th AD Regt) is part of the Royal Australian Artillery Corps and the garrison is based at Woodside Barracks, South Australia. The Regiment consists of four subunits: Head Quarters (HQ), 110 Battery (110 BTY), 111 Battery (111 BTY) and Combat Services Support (CSS). The Regimental Aid Post (RAP) is part of the CSS located at Woodside Barracks.

The path to become an Australian Army soldier requires two phases; recruit training and garrison training. Garrison training and activity is different from recruit training in Australia. Garrison soldiers at 16th AD Regt conduct intensive physical conditioning to maintain their physical fitness and strength, play competitive sports, and perform manual handling that is specific to their trade. Recruit training, on the other hand, is focused on teaching the new soldier how to conduct themselves in a military environment and the emphasis on physical training is much less. This current study is therefore important to demonstrate what effect training and military duties have on fully trained Australian soldiers in a garrison.

The 16th AD Regt RAP provides the regiment a morning sick parade, and as required, health checks (performed by medics), medical assessments and reviews (performed by the Medical Officer (MO)), dental, psychological support, physiotherapy assessment and treatment (performed by the physiotherapist), and gym rehabilitation (performed by the physiotherapist and the Physical Training Instructor (PTI)).

The main purpose of the 16th AD Regt physiotherapy service is to provide a medical capability to maximise the number of fully fit soldiers for deployment by providing physiotherapy treatment and rehabilitation. This service not only is a force multiplier (an attribute which makes a given force more effective than that same force would be without it) but also reduces the morbidity of soldiers and the fiscal cost to the ADF. Strowbridge and Burgess (2002) have stated that rehabilitation is a cost effective method of treating soldiers with musculoskeletal injuries. Referred patients to 16th AD Regt physiotherapy are treated as outpatients and are normally able to continue in their job within the regiment but often with restrictions as dictated by the Medical Officer.

Injury prevention and maintaining high levels of fitness is an important factor in a unit such as 16th AD Regt as it bolsters its operational effectiveness. Strowbridge and Burgess (2002) suggest that there are five steps in injury control; "surveillance to determine the scale of the problem; determination of the cause of injury; studies to ascertain if the proposed method of intervention is effective; implementation of the intervention and audit of effectiveness". It is with this in mind that this study has been conducted, to ascertain the scale, type and cause of musculoskeletal injury that was occurring at 16th AD Regt so that preventative intervention strategies could be initiated and directed.

Soldiers who require physiotherapy treatment and rehabilitation are referred by the Medical Officer. All physiotherapy and rehabilitation occurs on site, as there is a well equipped physiotherapy treatment room, gym and hydrotherapy facilities. There is a close liaison between the physiotherapist and the PTI in regards to transitioning patients from direct physiotherapy injury rehabilitation to Battery physical training programs. In addition, the physiotherapist conducts physical assessments on all new members entering the unit, as well as Physical Employment Assessments to determine if a rehabilitated injured member is physically able to return to his trade without restrictions.

The key objectives of this study are:

- To investigate the predominant injuries sustained by 16th AD Regt soldiers;
- To investigate whether there are any patterns of injury among the Regimental subunits; and
- Whether there is any association between type of injury and cause of injury.

This study was conducted because there is a lack of information about the types of injuries and injury patterns in relation to Australian garrison soldiers. Moreover, there is scant information about injuries sustained by garrison soldiers internationally that explores patterns such as the association between type of injury and cause. One study by Strowbridge and Burgess (2002) does focus on types of injury and some injury patterns sustained by British garrison soldiers. More generally there are some studies of association in other parts of the military setting, such as Cox et al. (2000) which focuses on the association between one particular type of injury and the history of injury for recruits.

It is envisioned that, following this current study, future strategies can be developed in an attempt to reduce the occurrence of injury and thus to enhance the operational readiness of the 16th AD Regt. Once formulated and tested, preventative programmes could ultimately be rolled out to other units of the Australian Defence Force.

Materials and methods

The 16th AD Regt consists of four subunits: Head Quarters (HQ), 110 Battery (110 BTY), 111 Battery (111 BTY) and Combat Services Support (CSS). It has a nominal roll of 338 personnel (HQ = 43, 110 BTY = 120, 111 BTY = 100, CSS = 75) with 98% being male and

2% being female. The soldiers had all completed basic training, the majority having been in the Australian Army for many years. The average age range per subunit was as follows: HQ = 36 years (range 23-50); 110 BTY = 26 years (18-54); 111 BTY = 25 years (19-43); CSS = 33 years (19-56).

The inclusion criteria for this study were all physiotherapy patients diagnosed with a musculoskeletal injury from 01 January 2008 to 31 October 2010, and subsequently discharged from their treatment after their condition resolved. The condition was either acute or chronic in nature and was assessed and treated by the physiotherapist on site. Patients were referred to physiotherapy by the Medical Officer.

Presented conditions were assessed using the Australian physiotherapy criteria of Subjective, Objective, Assessment and Plan (SOAP), in which Subjective identifies the area and cause of the injury and the Objective examination identifies the injured structure through a range of movement and palpation.

Upon discharge from physiotherapy treatment, the date of the first and last assessment, number of treatments received, the diagnosis, treatment method used, the mechanism of injury (cause), outcome, and the member's subunit were recorded on the Specialist Report (PM 528) 'physiotherapy discharge summary' and filed in the patient's medical records. It is this data from the PM 528 that has been used in the conduct of this study.

Analysis of the data will be based on chi-square tests of independence to test the relationships between variables and the chi-square goodness of fit test to test the equality of frequencies at the 0.05 significance level (see, for example, Triola and Triola, 2005). When the chi-square test of independence is significant, then the cause of the dependence is investigated by analysis of standardised residuals for each cell with Bonferroni adjustment of the significance level by dividing 0.05 by the number of standardised residuals to be examined. Minitab 16 statistical software was used to carry out statistical analysis.

Results

A total of 430 physiotherapy discharges were made over the three years 2008 to 2010 following the treatment and/or rehabilitation of the patient's condition. These discharges represent 99% of all new referrals made to physiotherapy over the three years of this study, and the remaining 1% being new referrals that failed to attend physiotherapy, so therefore, could not be assessed or treated by the physiotherapist. Discharged patients rather than new referrals to physiotherapy were used for this reason.

The scope of this study is limited to injury type, number and cause and has limitations in regards to the small sample number,and use of the valid outcome measures and reliability of those measures.

After considering the physiotherapy discharges, five main types or areas of injury were identified: neck, low back, ankle, patella, and knee ligament. While other types of injury were recorded, these five types were chosen for analysis because they are the types for which thirty or more injured soldiers were observed over the period 2008 to 2010 – totalling 242 injured soldiers for those five types. These five types or areas of injury are defined as;

- 'Neck': an injury to the cervical spine involving a ligament or facet joint sprain or dysfunction;
- 'low back': an injury to the lumbar spine involving a facet joint sprain or dysfunction or paravertebral muscular strain or disc tear/bulge;
- 'Ankle': an inversion sprain injury involving the lateral ligament structures of the ankle (anterior talofibular ligament and calcaneofibular ligament and possibly strain to the peroneus longus and brevis);
- 'Patella': patella-femoral joint inflammation; and
- 'Knee ligament': a strain injury to the medial or lateral collateral ligaments or the cruciate ligaments.

An investigation was first conducted to assess if there was any evidence of a relationship between the type of injury and the year, that is, whether the type of injury differs in frequency in relation to the year. Statistical analysis found there was insufficient evidence of a relationship between the type of injury and year (based on a chi-square test of independence, $p = 0.32$). Given that we found there is no relationship between the type of injury and year, the physiotherapy discharge data can be aggregated to consider the total over the three years (2008 to 2010) when considering other variables in the subsequent analyses.

Next to be considered was whether each type of injury was equally likely to occur, that is, whether the frequency of neck, low back, ankle, patella and knee ligament injuries are the same. The data to be analysed is presented in Table 1.

Type of injury	
Neck	0.18
Low back	0.36
Ankle	0.14
Patella	0.16
Knee ligament	0.16
Total injuries	**242**

Table 1: Frequency data for type of injury

Statistical analysis, using a chi-square goodness of fit test, found there was evidence that the frequency of injury is not the same for each type of injury ($p < 0.001$). Thus it is appropriate to further investigate which particular types of injury are observed to be significantly different to what would be expected if the frequency of each type of injury was assumed to be equal. To do so, analysis of standardised residuals, using a Bonferroni adjustment, was used.

Based on a significance level of 0.05 and that 5 standardised residuals are to be examined (one for each type of injury), then the Bonferroni adjustment results in a significance level of 0.01 and a critical value of 2.576. Based on this, the observed frequency of low back injuries was found to be significantly greater than expected. In other words, we found that there is a relatively higher frequency of lower back injuries compared to other types of musculoskeletal injury.

It was then investigated whether there was any evidence of a relationship between the type of injury and subunit, that is, whether the type of injury differed in frequency in relation to which subunit a soldier belonged (HQ, 110 BTY, 111 BTY or CSS). Statistical analysis found there was insufficient evidence of a relationship between type of injury and subunit ($p = 0.33$).

The final aspect of this current study was to investigate whether there was a relationship between the type of injury and cause. There are five types of injury under study, and it was found from the data set that there were five main causes of injury, described as follows:

- Biomechanical: where there was no known specific identifiable incident, but pain was brought on by a muscular-neural-skeletal dysfunction (an intrinsic factor).
- Work: where injuries arose from manual handling which is typically carried out by 16th AD Regt soldiers or from prolonged sitting while using a computer.
- Running: where an injury arose from long distance running greater than 2km on level and graded surfaces. Running is aimed at maintaining cardiovascular fitness and is a requirement to pass a basic fitness assessment requirement of the Australian Army.
- Sports: involves ballistic movement and changes in direction (such as in volleyball, touch rugby, basketball and soccer) that could contribute to injuries. Sport is aimed at developing qualities such as team building and fitness and is held periodically through out the year.
- Physical Training: where injuries arose from daily 1-hour circuit based exercise programs conducted each day by a Physical Training Instructor (PTI) or Combat Fitness Leader (CFL). The circuit consists of a variety of different types of exercises at varying levels of difficulty and effort designed to improve both cardiovascular endurance and strength and can involve lifting weights or repetitious movements under load.

Each of those five causes of injury consisted of a count of at least 20 injured soldiers over the duration of the study and other causes were excluded from further investigation. Thus the five main causes of injury are the only causes to be considered further, along with the type of injury. The corresponding total number of injured soldiers over the variables type of injury and cause is 185. We will investigate whether there is evidence of a relationship between type of injury and cause.

The results of statistical analysis found there was evidence of a relationship between type of injury and cause ($p < 0.001$). Thus it is appropriate to subsequently examine standardised residuals for each of the 25 combinations of a particular type of injury and cause as follows.

Based on a significance level of 0.05 and that 25 standardised residuals are to be examined (one for each combination of type of injury and cause), then the Bonferroni adjustment results in significance level of 0.002 and a critical value of 3.09. Based on this, the following statistically significant results are obtained:

- for the combination of ankle injury and sports, the observed frequency is significantly greater than expected and,
- for the combination of patella-femoral injury and running, the observed frequency is significantly greater than expected.

Put another way, the cause of injury 'sports' is associated with a relatively higher frequency of ankle injury. Running is associated with a relatively higher frequency of patella-femoral joint injury.

Furthermore, the following results, close to significance, may also be important:

- for the combination of neck and biomechanical, the observed frequency is greater than expected ($p = 0.012$),
- for the combination of neck and running, the observed frequency is lower than expected ($p = 0.033$),
- for the combination of low back and work, the observed frequency is greater than expected ($p = 0.006$),

- for the combination of low back and running, the observed frequency is lower than expected ($p = 0.019$),
- for the combination of lower back and sports, the observed frequency is lower than expected ($p = 0.004$),
- for the combination of patella and work, the observed frequency is lower than expected ($p = 0.01$) and
- for the combination of knee ligament and sports, the observed frequency is greater than expected ($p = 0.003$).

Those results that are close to being statistically significant could form the basis of a future study.

Discussion

This study has been approved by the Australian Defence Human Research Ethics Committee (ADHREC) with the designated research protocol number 628-11.

One of the major findings of our study was that there was a significantly higher frequency of low back injuries relative to other types of injury for 16th AD Regt soldiers. It is noteworthy that Strowbridge and Burgess (2002) found in their study that the most common type of injury observed among British soldiers was low back. However, unlike this current study, they did not support their finding with statistical analysis.

We found that work involving manual handling or long periods of sitting is associated with a relatively higher frequency of low back injury in Australian soldiers at 16th AD Regt, which was close to statistical significance. McGill (2007) states that "known tissue damage occurs with high magnitudes of load, repetition, and so on", and refers to studies in the epidemiological literature that have found that musculoskeletal injuries were twice as likely with compressive forces exceeding 6800 N, and in particular, cumulative loading, joint moments and spine shear forces are important as risk factors for low back disorders. Studies from Finland, Denmark and Switzerland (Ulaska J et al. 2001, Darre EM et al. 1999, Rohrer MH et al. 1994) have also outlined the impact of low back pain on military service and have concluded that the main factors in the aetiology of this condition were lifting, carrying, standing for long periods of time, twisting and heavy work. Furthermore, they also found from follow up studies that re-occurrence of low back pain increased during military service and was a major cause of time off work after discharge. Many of these same movements and often under loads of up to 45 kg individually or a combined two man lift of 65 kg are required to be performed routinely by Australian soldiers in their trade such as Ground Based Air Defenders, Craftsman, or in catering in 16th AD Regt and may explain the association between 'work' and low back injuries found in our study. McGill (2007) also states that an extended period of sitting is a factor in lumbar disc pathology, and cites Kelsey (1975) who discovered a specific link between prolonged sitting and the incidence of lumbar disc herniation. McGill (2007) further states that "more upright sitting postures, and the concomitant psoas and other muscle activation, impose additional compressive loads on the spine", that may provide a possible explanation for the association between long periods of sitting and low back pain found in our study. He recommends a variable posture whilst sitting as a strategy to minimise the risk of tissue overload.

However, McGill (2007) also states that "the majority of specific risk factors that are addressed in the epidemiological literature (which is surprisingly sparse) are really surrogate factors, or indirect measures, of spine load, [consisting of] static work postures; seated work postures; frequent bending and twisting; lifting, pulling, and pushing; and vibration (especially seated)". These indirect measures were used in our study since specific characteristics of the work and the risk of suffering low back injury, or direct tissue loads in an epidemiological study were beyond the scope of this study and this may therefore be a limitation to the study. Although McGill (2007) found that several studies have not been able to support a link between heavy work and the risk of low back disorders, he does state that "there is no question that damage to tissue can be caused by excessive loading, and damage causes pain". Further research in this area may help to clarify this vexed question, with this current study forming the basis of future investigation into core related muscle strengthening as a preventative strategy.

We found in this current study that the association between neck injuries and a biomechanical cause is a result that is close to statistical significance in Australian soldiers at 16th AD Regt. McGill (2007) states from his literature review that with regards to spinal pain, low muscle forces result in a small motor error that causes rotation of a single spinal joint, thereby placing all the bending moment onto the passive tissues resulting in injury. He further states that "deficient motor control mechanisms heighten biomechanical susceptibility to injury or re-injury and that some biomechanical based studies, together with the chronic pain literature, are strongly convincing in their establishment of both association and causality". These factors could explain the biomechanical reason for the injuries suffered by Australian soldiers at 16th AD Regt. The study by Grob et al (2007) suggested that vertebral alignment was not a factor since there was no association between sagittal alignment of the

cervical spine (or its individual segments) and the presence of neck pain. Moreover, Grob et al (2007) found that "in the group with neck pain, there was no relationship between curvature and any index of symptom severity, such as pain intensity, disability, healthcare utilisation, etc". The nature of why biomechanical factors may be associated with neck pain found in our study remains unclear and it would be of interest to investigate this with a further study.

Our study found that the cause 'sports' is associated with a relatively higher frequency of ankle injuries in Australian soldiers at 16th AD Regt, and that this result is statistically significant. Ankle injuries to 16th AD Regt soldiers usually involve injury to the lateral ligament structures of the ankle in an inversion sprain. Strowbridge and Burgess (2002) commented that the ankle is the most common injury to occur as a result of sports in their study of British soldiers, although their finding is not supported by statistical analysis. The reason why sports is associated with ankle injury might be explained by Kofotolis et al (2007) who reported that most ankle injuries were from contact games, where there are high lateral or medial forces on the foot causing excessive musculoskeletal loading and inversion, rather than non-contact (landing, twisting, turning and running), and suggested that these movements are very frequent in sports, inducing high joint and musculoskeletal forces. These observations could offer an explanation as to why ankle injury occurs to Australian soldiers at 16th AD Regt while playing sports. They also found, upon reviewing the literature on ankle sprains, that there is little consensus with regard to whether variables such as age, height, weight, or limb dominance are risk factors for ankle sprains. If these variables are risk factors of 16th AD Regt soldiers then they were beyond the scope of this current study. A recommendation for increasing ankle support possibly by strapping or a brace was put forward by Strowbridge and Burgess (2002) to help reduce the incidence of ankle injury and is one measure that could be instigated in the 16th AD Regt.

We also found that the cause 'sports' being associated with a relatively higher frequency of knee ligament injuries in Australian soldiers at 16th AD Regt is a result that is close to significance. The study of ACL injuries made by Krosshaug et al (2007) found that these injuries can be attributable to involved joint kinematics, playing situation and player behaviour. In their study they found that although injuries can be through contact with the opponent, the majority of injuries did not involve contact at the assumed point of injury and that many players' movement patterns were also influenced by perturbations by an opponent (being pushed or in a collision) before the time of injury. They also observed that injuries occurred during landing with knee flexion angles at the assumed point of injury. An explanation as to why knee ligament injuries occur during sports in 16th AD Regt Australian soldiers could possibly be attributed to these same observations.

Our study found that running is associated with a relatively higher frequency of patella-femoral injury to 16th AD Regt soldiers and this is a statistically significant result. Buist et al (2008) state that most running related injuries to the lower extremity is from overuse and are related to lack of running experience, previous injury, running to compete and excessive weekly running distance. They also state that 60% of these can be attributed to running too much too soon. However, although they state that the knee and lower leg were the most injured body parts in their study they do not specify what structure in the knee is injured as their focus was on how a graded running programme affected such injuries and was conducted on novice runners.

Australian soldiers of the 16th AD Regt perform regular running programmes to both maintain their cardiovascular fitness and in order to pass a basic fitness assessment (BFA), which incorporates a 2.4 km distance running component and is an Australian Army requirement. What is too much running to cause knee injury and what is enough to effect a beneficial change to the knee to tolerate such stressors is still undetermined and is likely to be highly variable between individuals. Buist et al (2008) states that "more research is needed on the relationship between intensity, frequency, and the duration of training and injury risk, and other potentially possible risk factors and when there is inadequate time between stress applications, an overuse injury can occur". Further research is required in running as performed by Australian soldiers, to assess the relationship between these four variables.

Conclusion

This is the first full review of data on musculoskeletal injuries sustained by the Australian soldiers of the 16th Air Defence Regiment. Types of musculoskeletal injuries and their causes were analysed and patterns of injury were identified. From this study it is recommended that further research is conducted into ways of reducing the risk of musculoskeletal injuries in Australian soldiers. This could be achieved by core muscle activation and strengthening programmes and regular breaks from long periods of sitting with a range of movement exercises to reduce low back injuries, the use of ankle supports during sporting activities to reduce ankle injuries, and the optimum distance: time ratio to reduce knee injuries. This

study may form the basis of further research in the hope to reduce the rate of musculoskeletal injuries to Australian soldiers.

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