**MUSCULOSKELETAL INJURY IN MILITARY SPECIALISTS: A TWO-YEAR RETROSPECTIVE STUDY**

D Hayhurst, M Warner, M Stokes and J L Fallowfield

**ABSTRACT**

**Background**

Military Specialists are elite personnel who are trained to work across diverse operational environments where a high level of physical conditioning is a prerequisite for their role. Anecdotally, personnel are acknowledged to be at high risk of developing musculoskeletal injuries (MSKI). However, there are presently no published data on this UK military population to support this view. This is the first (two-year) retrospective epidemiological study to identify the MSKI sustained by this military population.

**Methods**

All MSKI reported over a two-year period (Jan 2018 – Dec 2019) were recorded to identify the incidence, frequency, nature, onset, cause, location and reporting times. Injuries were described using injury count and relative frequency (percentage). Time at risk for each personnel day was calculated as 365 days.

**Results**

A total of 199 personnel reported 229 injuries over the reporting periods. The injury incidence rates were 26.8 personnel per 100-person years (2018) and 27.7 personnel per 100-person years (2019), respectively. Military training accounted for the highest number of injuries (32%), followed by ‘Other Injuries’ (28%), Personal Training (PT) (28%) and Sport (12%). The leading activity associated with injury was weight training (15%), followed by running (11%) and military exercise (10%). Lower extremity injuries accounted for the highest number of injuries (40%), followed by trunk (36%) and upper extremity (24%) injuries.

**Conclusion**

This study identifies the MSKI profile of a Military Specialist population over a two-year period. Areas where modifiable risk factors may be identified to reduce risk of injury are highlighted. Recommendations for further research include investigating injury burden and the impact of injury on operational readiness.

**Key Messages**

**What is already known on the topic:**

* Musculoskeletal injury is the primary cause of medical downgrade in the military

**What this study adds:**

* This study identified the previously unknown injury profile in a Military Specialist Unit.
* The main activities associated with injury were weight training and running, where the most common injury locations were identified as lower back, shoulder and knee

**How this study might affect research, practice or policy**

* Further research is required to determine injury burden and the impact of injury on operational readiness in this population

**INTRODUCTION**

Musculoskeletal injury (MSKI) is the primary cause of medical downgrade in military populations due to the highly physical nature of the occupation and associated physical training required to meet those demands1. A physically fit military is better able to achieve mission success and will ensure increased resilience to the demands of the battlefield2. Recognising that MSKI can severely impact the readiness of a military unit due to a loss of workforce and an individual’s time away from the role, there is a requirement to develop targeted mitigation strategies to reduce MSKI and maintain an effective and deployable workforce. Similarities can be drawn between Military Specialist and sporting populations due to the necessity of, and involvement in, vigorous physical training and activity. The most common model of injury prevention used within sporting populations is the van Mechelen four-step ‘sequence of prevention’ which was later expanded by Finch3. The first step in the model is to describe the magnitude of the injury problem which is typically measured through epidemiological studies. The subsequent steps identify aetiology and mechanism for injury with the purpose of developing suitable preventative measures. The measures are then implemented and assessed for efficacy within the implementation context before repeating stage one to determine effectiveness of the prevention measures Within the UK Armed Forces a number of studies have focused on injury surveillance within recruit training4 however at present there is a dearth of data describing the scale of MSKI within trained personnel5. Thus, an understanding of MSKI epidemiology is critical as the first stage to ensure the development of appropriate mitigation strategies to reduce MSKI risk.

Military Specialists are elite personnel who are trained to work across diverse operational environments where a high level of physical conditioning is a prerequisite for their role. Anecdotally it is recognised that this specific UK military population are at risk of developing MSKI due to the physical demands and training associated with the role. However, there are presently no published injury epidemiology data in this UK military population to support this view. A recent systematic review on global military populations who undertake similar roles identified that between 20% and 50% of qualified personnel sustained at least one injury within a 12-month period6. Due to the paucity of literature on this UK military population, there is a need to understand the injury profile to provide an evidence base for the development of mitigation strategies. The purpose of this descriptive epidemiological study was to describe the incidence and nature of reported MSKI sustained by personnel over a two-year period.

**METHODS**

**Study Design**

A two-year retrospective review of reported MSKI was undertaken on all new Military Specialists who attended a Primary Care Rehabilitation Facility (PCRF) at a Military Unit between 01 January 2018 to 31 December 2019. Information was extracted from patient medical records held on the Defence Medical Information Capability Programme (DMICP) and a new patient injury database held by the PCRF. Permission for the review was granted by the Medical Officer of the Unit in accordance with Caldicott guidelines, permission to access DMICP was granted by the Practice Manager, as the Medical Centre Caldicott lead.

**Injury Definitions**

At the time of reporting there was no consensus statement in the Defence Medical Services for injury definitions in epidemiology studies. For the purpose of this study, injury definitions have been adapted from elite sport consensus statements7-9 and informed by subject matter expert guidance. The following information was extracted from new patient medical records and the injury database for use in the study.

1. *Nature of Injury*. Identified as either a new injury (patient had not experienced nor reported pathology at the specific injury site), or a recurring injury (patient had experienced previous or ongoing pathology at the injury site).
2. *Onset of Injury*. Identified as sudden (specific or known cause of injury) or gradual (non-specific or unknown cause of injury that had developed over time) onset.
3. *Reporting Time of injury*. Reporting time of injury was identified as the time from onset of injury until attendance at the PCRF appointment.
4. *Primary Cause of Injury*. The principal cause of injury was categorised according to the following activities:
5. Military Training.
6. Personal Training.
7. Sport.
8. Other (all activities that could not be classified into the previous categories)
9. *Secondary Cause of Injury*. The secondary cause of injury was identified as individual tasks that had previously been identified as general causes of injury within military populations.
10. *Anatomic Location of Injury*. The primary location of injury describes a broad anatomical region and was identified according to the following categories:
11. Upper Extremity.
12. Lower Extremity.
13. Trunk.
14. *Sub-Anatomic Location of Injury*. Primary locations of injuries were further classified into specific anatomical areas as outlined below:
    1. Upper Extremity: Shoulder, upper arm, elbow, wrist and hand.
    2. Trunk: Cervical, thoracic, lumbar, pelvis/SIJ, chest and abdominal.
    3. Lower Extremity: Hip, groin, quadriceps, hamstring, knee, tibia, calf, lower leg, ankle and foot.

All data were coded into a password protected Microsoft Excel spreadsheet on a military secure computer. Access was restricted to the Primary Investigator.

**Analysis**

Injuries were described using injury count and relative frequency (percentage). Time at risk for each personnel day was calculated as 365 days. Injury incidence and frequency were calculated using the standard equations detailed below:10,11

Injury incidence rate (per 100 person years) = (personnel with one or more injuries/total time at risk) x 100

Injury frequency rate (per 100 person years) = (new injuries/total time at risk) x 100

**RESULTS**

**Number of Injuries**

A total of 199 personnel reported 229 injuries over the reporting period. The nature and onset of injury are presented in Table 1. The injury incidence rates for 2018 and 2019 were 26.8 personnel per 100-person years and 27.7 personnel per 100-person years, respectively. The injury frequency rates are presented in Table 2.

Table 1. Nature and onset of injury in personnel.

|  |  |  |
| --- | --- | --- |
|  | **2018**  **Injury Count (%)** | **2019**  **Injury Count (%)** |
| **Nature of Injury** |  |  |
| **New** | 78 (66%) | 63 (57%) |
| **Recurring** | 40 (34%) | 48 (43%) |
|  |  |  |
| **Onset of Injury** |  |  |
| **Sudden** | 57 (48%) | 58 (52%) |
| **Gradual** | 61 (52%) | 53 (48%) |

Table 2. Injury Frequency Rates in personnel.

|  |  |  |
| --- | --- | --- |
|  | **2018** **Injury Frequency Rate**  **(Number of Injuries/100-person years)** | **2019 Injury Frequency Rate**  **(Number of Injuries/100-person years)** |
| **All Injury** | 32.3 | 30.4 |
| **New Injury** | 21.3 | 17.3 |
| **Recurring Injury** | 11.0 | 13.15 |
| **Sudden Onset Injury** | 15.6 | 15.9 |
| **Gradual Onset Injury** | 16.7 | 14.5 |

**Reporting Time of Injury**

Forty three percent of patients reported an injury within 1 month of onset. A further 19% reported an injury within one to three months, and 27% reported an injury after a year of onset (Figure 1)

|  |
| --- |
|  |
| Figure 1.Reporting time of injury to PCRF. |

**Cause of Injury**

Military training accounted for the highest number of injuries (32%), followed by ‘Other Injuries’ (28%), Personal Training (PT) (28%) and Sport (not PT) (12%) (Figure 2). Weight training accounted for the most injuries across the reporting period (15%) followed by running (11%) and military exercise (10%).

|  |
| --- |
|  |
| Figure 2. Primary cause of injury in personnel. |

**Location of Injury**

Lower extremity injuries accounted for the highest number of injuries (40%), followed by trunk (36%) and upper extremity (24%) injuries (Figure 3). Lumbar spine accounted for the highest number of injuries across the reporting period (19%) followed by shoulder (17%), knee (14%) and cervical injuries (11%) injuries (Table 3).

|  |
| --- |
|  |
| Figure 3. Anatomical location of injury in personnel. |

Table 3. Sub-anatomical location of injuries in personnel.

|  |  |  |
| --- | --- | --- |
|  | **2018**  **Injury Count (%)** | **2019**  **Injury Count (%)** |
| **Upper Extremity** |  |  |
| Shoulder | 19 (16%) | 21 (19%) |
| Upper Arm | 1 (0.5%) | 2 (1%) |
| Elbow | 1 (0.5%) | 4 (4%) |
| Wrist | 1 (0.5%) | 3 (3%) |
| Hand | 0 | 3 (3%) |
|  |  |  |
| **Trunk** |  |  |
| Cervical | 15 (13%) | 10 (9%) |
| Thoracic | 2 (2%) | 8 (7%) |
| Lumbar | 23 (19%) | 20 (19%) |
| Pelvis/SIJ | 0 | 3 (3%) |
| Abdominal | 0 | 1 (0.5%) |
|  |  |  |
| **Lower Extremity** |  |  |
| Groin | 0 | 3 (3%) |
| Hip | 6 (5%) | 4 (4%) |
| Hamstring | 4 (3%) | 2 (1%) |
| Knee | 22 (19%) | 11 (10%) |
| Tibia | 0 | 1 (0.5%) |
| Calf | 8 (7%) | 3 (3%) |
| Lower Leg | 3 (3%) | 0 |
| Ankle | 7 (6%) | 8 (7%) |
| Foot | 6 (5%) | 3 (3%) |

**DISCUSSION**

The present study has identified the incidence, nature, onset, location and cause of self-reported MSKI across a two-year period. A total of 229 injuries were reported by 199 personnel with an injury incidence (calculated as the number of injured personnel per 100 soldier-years) of 26.8 and 27.7 for 2018 and 2019, respectively. When compared to wider global military populations who report injury incidence rates as between 20.8 and 49.26, the findings of the present study are towards the lower end of the range. Injury frequency rates for global militaries as reported by Stannard and Fortington6 range from 24.5 to 84.6 injuries per 100-soldier years which is a much wider range compared to findings of this study (32.2 and 30.4 for 2018 and 2019, respectively). The contrast in findings compared to wider studies may be due to variations in study methodologies and nature of the military role. The methodology of the present study collected data on all reported injuries over the study periods compared to wider studies where injury data was only recorded on study volunteers which is a smaller study population. Thus, if a high percentage of the study population presented with an injury it would result in a higher injury incidence and frequency rate overall.

New injuries (62%) were reported more frequently than recurring injuries. These findings could not be directly compared with other military MSKI epidemiological studies as most reports do not differentiate between new and recurring injuries; all reported injuries are generally classified as ‘new injuries’11-13. This approach with the military contrasts with that of elite sport, where injuries are frequently classified as new or recurrent, with specific definitions being detailed in consensus statements7-9. Recurrence occurs when there is an injury of the same type and at the same location as a previous injury after an individual’s return to full function8,9. It is reported, both within the military and sporting environment, that previous injury can increase the risk of sustaining a further injury7,14,15. Therefore, if seeking to develop an injury mitigation strategy, there is a requirement to identify the number of recurrent injuries; these could, in turn, provide a focus for an intervention approach. Recurrent injuries accounted for 38% of injuries in this study. However, what is not known are the factors that may have led to these injuries, including whether they were true re-injuries or exacerbations of existing injuries.

Onset of injury in the present study was described as sudden or gradual. Sudden onset is usually indicative of an acute traumatic injury with a specific mechanism. Gradual onset injuries present with a slow developing pathology, which may be caused by training load, biomechanics and/ or poor training technique14. The causes leading to gradual onset injuries could be modifiable risk factors and may be considered as areas for intervention when developing MSKI mitigation strategies. Across the two years of the present study, the onset of injury was evenly divided between sudden and gradual; this contrasts with findings in wider military populations. Wilkinson et al11 reported that 13% of injuries in Army Infantry personnel during pre-deployment training were due to ‘overuse’, whereas data from wider global militaries range from 26.9% to 33.8% of injuries being overuse6. These findings were substantially lower than the figures presented in the present study. This may be due to differences in terminology, where overuse injuries have been described as ‘*one exacerbated by activity and relieved by rest*’16 or ‘*due or related to long-term, repetitive energy exchanges resulting in cumulative microtrauma*’11. The present study classified all non-acute injuries (no specific or traumatic onset of injury) as gradual onset, which may account for the higher number reported. Variations in terminology for military injury surveillance presents a challenge as it does not allow for direct comparisons between studies. Taking into account the high number of gradual onset injuries identified in this study, modifiable risk factors associated with these injuries should be considered in the development of an appropriate physical training programme to address the underlying issues.

A number of studies in global military populations and UK Infantry soldiers have identified physical training as the leading cause of injury within military personnel11,13,14,16. These findings contrast with the present study, which identified military training (32%) as the leading primary cause of injury followed closely by personal training (28%) and ‘other injuries’ (28%). However, when looking at specific activities leading to MSKI, weight training (15%) and running (11%) were common activities associated with injury across a number of military populations6. Physical training is essential in military populations to maintain appropriate levels of fitness to meet the demands of the occupational role. This is especially pertinent for this specific military population who are frequently required to perform a number of demanding tasks at any given moment. It is also recognised that increased volumes of physical activity (i.e. exposure time) can lead to increased risk of injury17. The emergence and popularity of extreme conditioning programmes over recent years may also lead to an increased risk of injury through high intensity metabolic training and the inclusion of highly skilled technical movements including Olympic lifts eg power cleans and power snatch18. At present, more information is required to specifically understand factors leading to strength training and running related injuries. It is not known whether the injuries were due to poorly managed training load, insufficient warm-up/preparation prior to the activity, poor technique used when executing the activity or the increased use of extreme conditioning programmes. Improved understanding of the factors leading to personal training injuries could inform future training programmes and education of those individuals at risk.

In the present study the lower extremity was the leading anatomical location for injury, which is in agreement with data from British Army Infantry11 and wider global military studies6. When considering sub-anatomical locations for injury within the UK Armed Forces, the most prevalent locations for MSKI are the lower back, knee, ankle and foot19. This contrasts with findings from the present study, which identified the lower back (19%) shoulder (17%) and knee (14%) as the most prevalent injury locations. Whilst it is unusual for shoulder injuries to be highly prevalent in UK Armed Forces11, it appears to be a common location for injury in certain US military personnel12,13. It is recognised that military personnel have a 5-18 times increased risk of shoulder instability injuries compared with the general population, and those with a history of shoulder instability are five times more likely to re-injure20. The exact pathology of shoulder injuries was not identified in this study. However, a review of data indicated that *circa* half (55%) of the injuries were sudden onset, which could be indicative of an acute trauma including dislocation or subluxation. Furthermore, 35% of personnel presented with recurring shoulder injuries, which indicated that previous injury may be considered a risk factor for further injury20. Analysis of the activities leading to shoulder injuries identified strength training as the leading cause of injury (25%). This is an area for further investigation to better understand the factors associated with shoulder injury in this population.

The majority of injuries (62%) were reported within three months of initial onset, but there were a high number of injuries (27%) reported one year after onset. It is unknown why there was a delay in reporting for these personnel. This may be due to: lack of access to physiotherapy (away in foreign locations or away from unit during the working day); lack of availability of physiotherapy appointments to meet the available timings of personnel; or fear of being medically downgraded for an injury that could impact opportunities to deploy and to continue in an operational role. This is an area that requires further investigation to ensure timely access for treatment of MSKI.

The present study has provided information regarding the incidence, nature, location and cause of MSKI. However, it is not able to provide evidence of injury impact or burden on operational fitness and therefore the ability of personnel to continue in role whilst carrying or being treated for an injury. It is critical to collate this information in order to understand where to prioritise efforts on injury mitigation efforts. Such insights would ensure that the development of evidence-based treatment pathways are focussed on those injuries that have the greatest impact to unit readiness. In addition, it would provide evidence to better financially and medically target resources to deliver greatest effect in supporting operational outputs.

**Limitations of the Study**

There were a number of acknowledged limitations to the present study. All data extracted and analysed from DMICP were reliant on the accuracy and precision of clinicians entering the medical information. For those personnel who reported their injuries a number of weeks after the initial onset, there may have been recall bias as to the exact nature, causes and additional factors leading to the injury. This study focused on reported injuries, which may not provide a complete representation of the injury burden and profile within the unit. Personnel may not report injuries due to issues of access to support, and concerns about the perceived implications and/ or consequences of reporting an injury. At present there is no consensus statement for the definition and description of terminology relating to injury epidemiology within the UK and international militaries. This may lead to discrepancies and/ or errors in reporting injury epidemiology, and difficulty in comparing injury data sets within military populations – locally and internationally. In accordance with MOD policy, full demographics of the study population have not been published limiting the ability to reproduce this study in wider military populations.

**CONCLUSION**

Military Specialists participate in rigorous physical training in preparation to meet the demands of the role. The present study has provided evidence that physical training, specifically weightlifting and running, may be a leading cause of injury within this military population. In addition, the findings indicate that a number of injuries are of a gradual onset and recurrent in nature, which highlights areas where modifiable risk factors may be targeted to reduce risk of injury. Injury mitigation strategies should focus on these areas with the purpose of developing appropriate education and physical training programmes to reduce MSKI. Future research to understand injury burden and impact on operational readiness is also required.

**REFERENCES**

1. Wardle, S. L., and Greeves, J. P. (2017). Mitigating the risk of musculoskeletal injury: A systematic review of the most effective injury prevention strategies for military personnel. *Journal of Science and Medicine in Sport,* 20 (Supplement 4), S3-S10. doi:https://doi.org/10.1016/j.jsams.2017.09.014.
2. Szivak, T.K. and Kraemer, W.J. (2015) Physiological readiness and resilience: Pillars of militray preparedness. *Journal of Strength and Conditioning Research*, 29(11S), S34-S39.
3. Bolling, C., van Mechelen, W., Pasman, H.R. and Verhagen, E. (2018) Context matters: Revisiting the first step of the ‘Sequence of Prevention’ of sports injuries. *Sports Medicine,* 48:2227-2234.
4. Sammito, S., Hadzic, V., Karakolis, T., Kelly, K.R., Proctor, S.P., Stepens, A., White, G. and Zimmerman, W.O. (2021) Risk factors for musculoskeletal injuries in the military: a qualitative systematic review of the literature from the past two decades and a new prioritizing model. *Military Med Res,* 8, 66.
5. Scott, P.J. Musculoskeletal injury outcomes: A 2-year retrospective service evaluation of a UK defence primary health care rehabilitation facility (PCRF). *BMJ Mil Health,* 167:182-186.
6. Stannard, J. and Fortington, L. (2021) Musculoskeletal injury in military Special Operations Forces: a systematic review. *BMJ Mil Health,* 0:1-11. Doi:10.1136/bmjmilitray-2020-001692.
7. Fuller, C.W., Bahr, R., Dick, R.W. and Meeuwisse, W.H. (2007b) A framework for recording recurrences, reinjuries and exacerbations in injury surveillance. *Clin J Sport Med,* 17(3), 197-200.
8. Orchard, J.W., Ranson, C., Olivier, B., Dhillon, M., Gray, J., Langley, B., Mansingh, A., Moore, I.S., Murphy, I., Patricios, J., Alwar, T., Clark, C.J., Harrop, B., Khan, H.I., Kountouris, A., Macphail, M., Mount, S., Mupotaringa, A., Newman, D., O’Reilly, K., Peirce, N., Saleem, S., Shackel, D., Stretch, R. and Finch C.F. (2016) International consensus statement on injury surveillance in cricket: a 2016 update. *Br J Sports Med,* 0:1-7. Doi:10.1136/bjsports-2016-096125.

1. Timpk, T., Alonso J., Jacobson J., Junge A., Branco P., Clarsen B., Kowalski J., Mountjoy M., Nilsson S., Pluim B., Renstrom P., Ronsen O., Steffen K. and Edouard P. (2014) Injury and illness definitions and data collection procedures for use in epidemiological studies in Athletics (track and field): Consensus Statement, *Br J Sports Med,* 48:483-490.
2. Knapik, J.J., Jones, S.B., Darakjy, S.D., Hauret, K.G., Bullock, S.H., Sharp, M.A. and Jones, B.H. (2007) Injury rates and injury risk factors among US Army Wheel Vehicle Mechanics, *Military Medicine,* 172, 9:988 – 996.
3. Wilkinson, D.M., Blacker, S.D., Richmond, V.L., Horner, F.E., Rayson, M.P., Spiess, A. and Knapik, J.J. (2011) Injuries and injury risk factors among British Army infantry soldiers during pre-deployment training. *Injury Prevention,* 17, 381-387.
4. Abt, J.P., Sell, T.C., Lovalekar, M.T., Keenan, K.A., Bozich, A.J., Morgan, J.S., Kane, S.F., Benson, P.J. and Lephart, S.M. (2014) Injury epidemiology of U.S. Special Operations Forces. *Military Medicine,* 179, 1106-1112.

1. Lovalekar, M., Abt, J., Sell, T.C., Wood, D.E. and Lephart, S.M. (2016) Descriptive epidemiology of musculoskeletal injuries in Naval Special Warfare Sea, Air, and Land Operators. *Military Medicine*, 181, 64-69.
2. Jones, B.H., and Hauschild, V.D. (2015) Physical training, fitness and injuries: Lessons learned from military studies. *Journal of Strength and Conditioning Research,* 29(11S), S57-S64.
3. Parr, J.J., Clark, N.C., Abt, J.P., Kresta, J.Y., Keenan, K.A., Kane, S.F. and Lephart, S.M. (2015) Residual impact of previous injury on musculoskeletal characteristics in Special Forces Operators. *The Orthopaedic Journal of Sports Medicine,* 3(11), 1-7.
4. Lovalekar, M., Perlsweig, K.A., Keenan, K.A., Baldwin, T.M., Caviston, M., McCarthy, A.E., Parr, J.J., Nindl, B.C and Beals, K. (2017) Epidemiology of musculoskeletal injuries sustained by Navy Special Forces operators and students*. Journal of Science and Medicine in Sport*, <http://dx.doi.org/10.1016/j.jsams.2017.09.003>.
5. Eckard, T.G., Padua, D.A., Hearn, D.W., Pexa, B.S. and Frank, B.S. (2018) The relationship between training load and injury in athletes: A systematic review. *Sports Medicine,* 48:1929-1961.
6. Bergeron, M.F., Nindl, B.C., Deuster, P.A., Baumgartner, N., Kane, S., Kraemer, W.J., Sexauer, L.R., Thompson, W.R. and O’Connor, F.G. (2011) Consortium for health and military performance and American College of Sports Medicine consensus paper on extreme conditioning programs in the military. *ACSM,* 10(6):383-389.
7. Ministry of Defence (2021) Annual Medical Discharges in the UK Regular Armed Forces: 1 April 2016 to 31 March 2021. Defence Statistics. Viewed 15 February 2022. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/1001267/UK\_service\_personnel\_medical\_discharges\_\_financial\_year\_2020\_21.pdf
8. Poploski, K.M., Picha, K.J., Winters, J.D., Royer, S.D., Heebner, N.R., Lambert, B., Abt, J.P. and Lephart, S.M. (2018) Patterns and associations of shoulder motion, strength and function in MARSOC personnel without a history of shoulder injury. *Military Medicine,* 183: 685-692.