Musculoskeletal Injuries in UK Service Personnel and the Impact of In-Theatre Rehabilitation During Cold Weather Warfare Training – Exercise Cetus 2020

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ABSTRACT

Introduction

The Royal Marines provide the lead Service for UK Defence Mountain and Cold Weather Warfare capability. This is the first prospective study addressing musculoskeletal injury rates sustained during Cold Weather Warfare training, with the aim of informing injury mitigation interventions and assist military medical planning with respect to delivering primary care rehabilitation in theatre.

Methods

All musculoskeletal injuries were surveyed by the Forward Rehabilitation Team (Nov 2019-Mar 2020) during a Cold Weather Deployment to Norway (Ex CETUS 2019/20). The frequency, nature of injury (new or recurrent), onset (sudden or gradual), cause, location and exercise/ treatment outcome were recorded.

Results

Eleven percent (n=136 cases) of the deployed population (n=1179) reported a musculoskeletal injury, which were mainly 'new' (62%), and with a 'sudden' onset (64%). Injury rate was 17.8 injuries per 10,000 personnel days. The majority of injuries occurred due to military training (88%); specifically during ski-related (61%) and load carriage (10%) activities. The average Service Person treated by the Forward Rehabilitation Team improved from 'injured with restricted duties' to 'fully fit', and with an improvement in their self-reported Musculoskeletal Health Questionnaire from 33 to 45 over an average of two rehabilitation sessions. One hundred and seventeen Service Personnel were able to continue on Ex CETUS with rehabilitation in theatre, thus negating the requirement for aeromedical evacuation for continuation of rehabilitation in the UK. Nineteen patients were unable to continue their Cold Weather Deployment due to the nature of their musculoskeletal injury, and returned to the UK for continued care in firm base rehabilitation centres.

Conclusion

This study identifies the nature, causation, and injury location. It demonstrates the effectiveness of in theatre rehabilitation and the ability to treat patients when deployed. Recommendations are presented to support strategies to mitigate Musculoskeletal Injury risk during future Cold Weather Warfare deployments to Norway.

1.0 INTRODUCTION

Musculoskeletal injury is the leading cause of medical discharge in Royal Marines, accounting for nearly two thirds of discharges over the previous five years [1]. A reduction in workforce directly impacts operational preparedness, deployability and effectiveness due to loss of training days and/or removal of Service personnel from operational roles [2]. The Royal Marines provides the lead Service for UK Defence's Mountain and Cold Weather Warfare capability. To achieve this, 3 Commando Brigade deploys annually to Norway to conduct Cold Weather Warfare and ski touring training. This comprises three phases (Survival, Mobility and Warfare) cumulating in a Final Exercise testing newly-taught knowledge and skills.

Whilst Cold Weather Warfare training is an essential military activity, relatively little is known of the rates, mechanisms, causes, and risk factors for musculoskeletal injury in this environment. Preliminary data from a small-scale epidemiology study identified cross-country ski training as being associated with high injury rates necessitating evacuation back to the UK [3]. This represents a significant loss of training days, as well as organisational expense, and an enduring degradation of workforce capability due to the time required to rehabilitate and return personnel to full fitness. To better inform the development of appropriate mitigation strategies, and reduce musculoskeletal injury risk during training exercises, there is a requirement to better understand the nature, onset, location and causes of injury.

Primary care rehabilitation on UK Operations is delivered by a Forward Rehabilitation Team comprising a Physiotherapist and Exercise Rehabilitation Instructor. The purpose of this team is to locally assess, treat and manage care pathways for personnel, thereby contributing to force generation and operational preparedness. The effectiveness of forward based rehabilitation is recognised in the US military [4] and has been used in multiple UK operational theatres and overseas deployments. However, at present, there is limited published evidence to demonstrate efficacy of forward rehabilitation in the UK military context. The purpose of this study was to determine musculoskeletal injury rates and outcomes during a Cold Weather Warfare training exercise, to inform the development of appropriate injury mitigation strategies. In addition, the study assessed the efficacy of forward rehabilitation to assist future medical planning.

2.0 METHODS

A prospective injury surveillance study was undertaken by the deployed Physiotherapist during Cold Weather Warfare training (Ex CETUS; 21 Nov 2019-20 Mar 2020). All new and follow up patients seeking treatment for a musculoskeletal injury from the Forward Rehabilitation Team were included in the survey. Permission was granted by all Senior Medical Officers of 3 Commando Brigade and RNAS Yeovilton to undertake the service evaluation.

2.1 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 were adapted from elite sport consensus statements and US Military epidemiology studies [5], [9]. The following information was collated from the clinician's initial assessment notes.

a) Phase of Training. Course phase identified as either Survival, Mobility or Tactical.

b) Nature of Injury. Identified as either a new injury (i.e. patient had not experienced or reported pathology at the specific injury site), or a recurring injury (i.e. patient had experienced previous or ongoing pathology at the injury site).

c) Onset of Injury. Defined as sudden (a single identifiable episode or known cause) or gradual (non-identifiable episode of injury or unknown cause that developed over time).

d) Primary Cause of Injury. The principal cause of injury was categorised according to the broad descriptors of:

   i) Military Training.

   ii) Personal Training.

   iii) Sport.

   iv) Other (All activities that did not fit the preceding three categories).

e) Secondary Cause of Injury. The secondary cause of injury was identified as individual tasks that had previously been identified as general causes of injury during Cold Weather Warfare.

f) Anatomic Location of Injury. The injury location describes a broad anatomical region and was identified according to the following:

   i) Upper Extremity.

   ii) Lower Extremity.

   iii) Trunk/Spine.

g) Sub-Anatomic Location of Injury. Anatomic injury locations were further classified into the specific sub anatomical areas of:

   i) Upper Extremity: Shoulder, upper arm, elbow, wrist and hand

   ii) Lower Extremity: Hip, groin, quadriceps, hamstring, knee, tibia, calf, lower leg, ankle and foot

   iii) Trunk: Cervical, thoracic, lumbar, pelvis/sacroiliac joint (SIJ), chest and abdominal

2.2 Outcome Measures

Clinical outcomes were assessed using the Functional Activity Assessment Questionnaire (FAA) [10] and Musculoskeletal Health Questionnaire (MSK-HQ) [11]. Both questionnaires are recognised patient reported outcome measures that are routinely used in Defence Rehabilitation.

2.3 Analysis

Descriptive statistics were determined for musculoskeletal Injury data (Microsoft Excel 2016, USA). Injury rate was reported relative to the total deployed strength, and with reference to population at risk days (i.e. defined as the number of personnel days spent in theatre during the deployment). Data were captured for the daily population at risk using air manifests for people transiting-in and extracting-out of theatre during the Exercise. Injury incidence was calculated using standard equations [12]:

Injury incidence rate (per 1000-person days) = (personnel with one or more injury sustained / total time at risk in days) x 1000

3.0 RESULTS

3.1 Total Number of Patient at Risk Days

There were 78686 patient at risk days during the deployment with a mean of 894.16 (±68.6 95% CI) personnel deployed at any stage. This included all those deployed to Norway on winter exercise. There was no alternative rehabilitation care pathway for injured personnel deployed to Norway.

3.2 Number of Injuries

A total of 136 personnel (11%) reported a musculoskeletal injury during Ex CETUS. New injuries were reported more frequently (62%) compared with recurring injuries (38%). Injury onset was more frequently reported as sudden (65%) compared with gradual onset (35%) (Table 1). The overall injury rate was 1.72 injuries per 1000 person days.

Table 1: Nature and Onset of Injury during Ex CETUS.

	Injury Count (%)
Nature of Injury	
New	84 (62%)
Recurring	52 (38%)
Onset of Injury	
Sudden	89 (65%)
Gradual	47 (35%)

3.3 Phase of Training

Phase of training associated with injury occurrence is detailed in Table 2. Of the 376 personnel who completed the Cold Weather Survival Course, 26 suffered a musculoskeletal injury (7%). Of the 756 personnel who completed the Cold Weather Warfare course, 40 suffered musculoskeletal injury (5%).

Table 2: Injury Count of Personnel Specifically Injured during the Cold Weather Survival and Cold Weather Warfare Course.

Phase of Training	Cold Weather Survival Course	Cold Weather Warfare Course		Total
		Mobility	Tactical	
Count	26	29	11	66

3.4 Cause of Injury

Military training was the most common primary injury cause (n=120; 88%). Figure 1 details the secondary activities associated with injury causation.

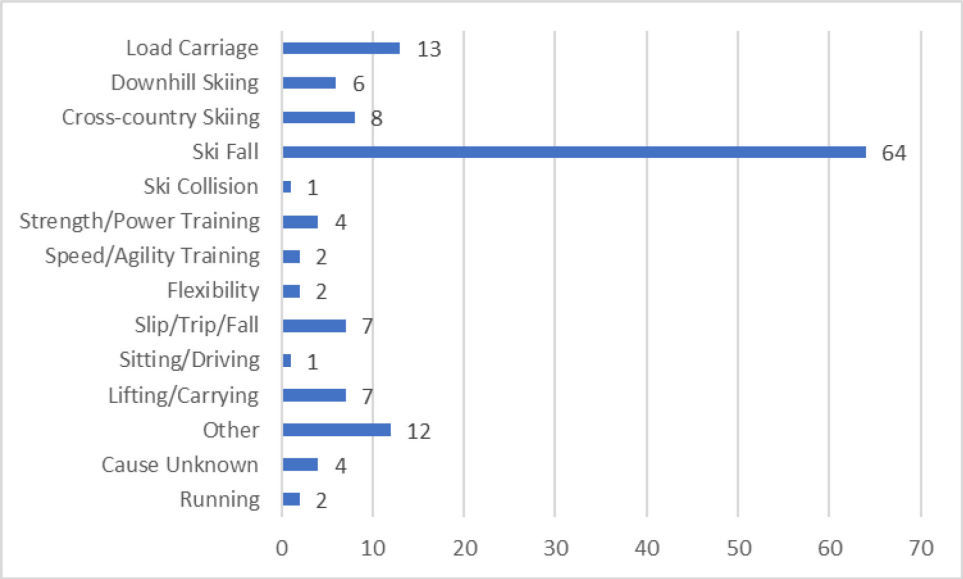

Figure 1: Secondary Cause of Injury to Service Personnel during Ex CETUS.

3.5 Location of Injury

The anatomic locations for injury were: lower limb (37%); upper limb (37%); and spine (26%). Figure 2 presents the sub-anatomic injury locations (i.e. specific anatomical structure). The most common injury locations were the shoulder, knee and lower back.

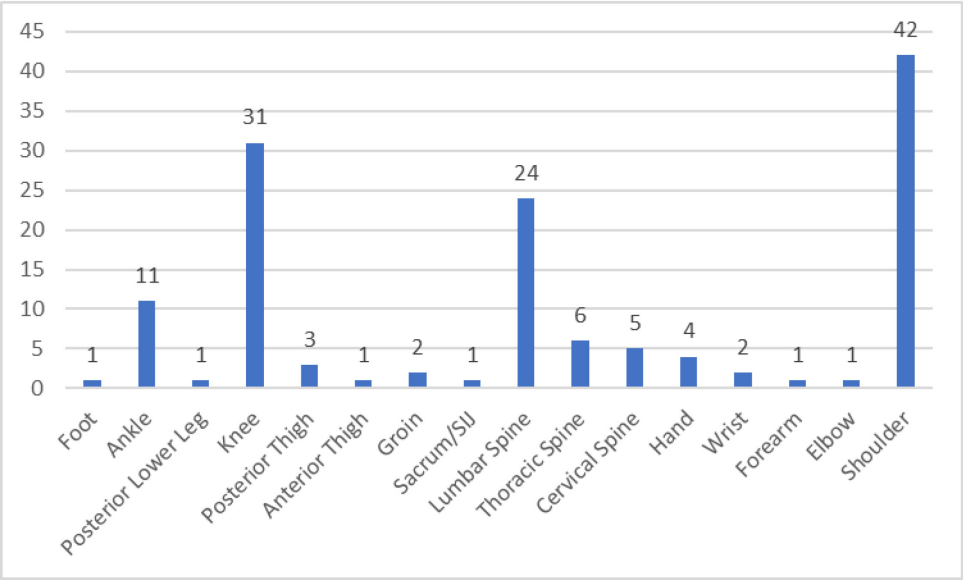

Figure 2: Sub Anatomical Injury Location of Personnel during Ex CETUS.

3.6 Rehabilitation Injury Outcomes

The outcomes for all injuries treated during Ex CETUS are presented in Table 3. The Forward Rehabilitation Team ensured that 74% (n=119) of all patients seen (3 Commando Brigade and Other) were rehabilitated in

situ and were able to continue with training, either fully fit or fit for role with minor pain. Seventeen patients were aeromedically evacuated to the UK due to musculoskeletal injury severity.

Table 3: Rehabilitation Outcomes of Service Personnel during Ex CETUS.

Outcome Measure	Outcome
Number of patients	136
Average FAA* on admission	2.8**
Average FAA on discharge	1.9**
Average MSK-HQ *** on admission	33**
Average MSK-HQ on discharge	45**
Average contacts per patient	2
Average days injured per patient on Exercise	25
Continued on EX CETUS (*n,* % of injured)	117 (86%)
Removed from EX CETUS (*n*, % of injured)	19 (14%)

* FAA (Functional activity Assessment): 1 = Fully Fit; 2 = Fit for trade and fit for restricted general of military duties; 3 = Unfit for trade but fit for restricted general or military duties; 4 = Unfit for all but sedentary duties; 5 = Off all duties

** Data treated as continuous variable

*** MSK-HQ – patient reported outcome measure which has been developed to assess outcomes in patients with a variety of MSK conditions. Highest level of ability = 55, highest level of disability = 0

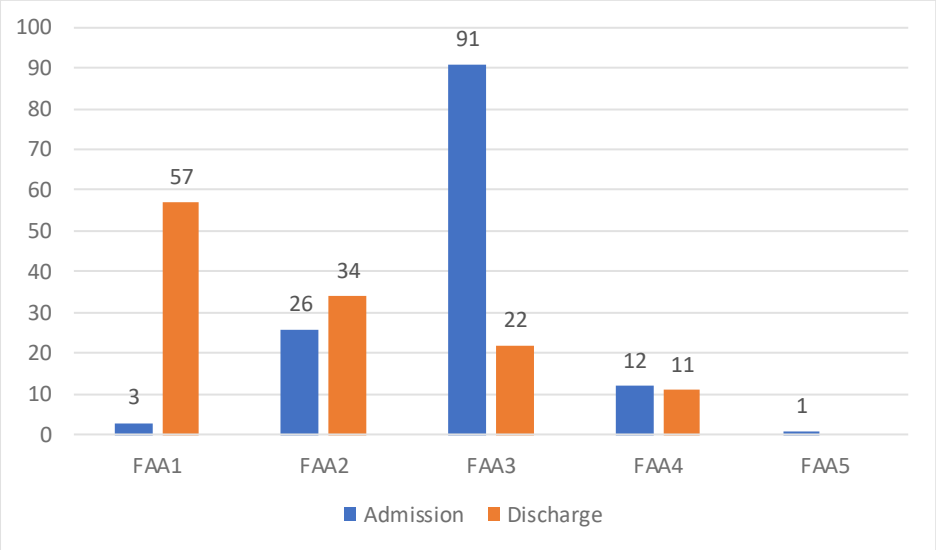

Figure 3: Functional Activity Assessment Outcome of Rehabilitated Personnel during Ex CETUS.

Admission FAA scores were recorded for all 136 injured personnel. Discharge FAA scores were recorded for 124 personnel with 8 discharge scores not completed. The average FAA on admission was 2.8 (Fit for Trade and fit for restricted military duties) and on discharge 1.9 (Fully Fit). Seventy admission MSK-HQ outcomes were recorded with 38 completed on discharge. Of the 38 completed MSK-HQ outcomes, 28 personnel demonstrated a minimal clinically important difference (change in score of above 6 [12]). Of the 136 personnel assessed, 117 were able to continue on Ex CETUS with rehabilitation in theatre, thus negating a requirement for aeromedical evacuation to continue rehabilitation in the UK.

4.0 DISCUSSION

This paper presents the first analysis of prospective data describing the musculoskeletal injury rate in Service personnel conducting modern Cold Weather Warfare training, and preliminary evidence supporting forward rehabilitation to in situ. This study identified the incidence, location and cause of injury in personnel undertaking the Cold Weather Warfare course, to inform future musculoskeletal injury mitigation strategies. During Ex CETUS (19/20), 136 personnel (11% of deployed population) reported a musculoskeletal injury. New injuries were reported more frequently than recurring injuries and were more likely to be of a sudden onset. The lead activity associated with injury was skiing activities, with the knee as the most common injury location. Of these injuries, 74% were retained in training with a significant restoration of their functional activity.

The overall injury rate in this study was 1.7 injuries per 1000-person days in theatre. This represented a lower arte of injury when compared to published data on UK trained and untrained personnel. Robinson et al [13] identified an incident rate of 3.5 recruits per 1000-person days for individuals undergoing initial Infantry training. It is recognised that the 26-week infantry training programme is physically demanding, and trainees are still physically maturing, which may in combination account for a higher injury rate [14]. Studies amongst trained infantry soldiers have identified injury rates of 59.1 soldiers per 100-person years [14]. It is challenging to directly compare the findings of this study with the Wilkinson et al [14] due to different methodologies in incidence reporting (1000-person days compared to 100-person years). However, the reported infantry injury rate is substantially higher than the present study. Wilkinson et all surveyed a year-long pre-deployment training cycle. In the present study, the total time an individual might spend on deployment ranged from one to four months; this may account for the variation in injury rates.

Approximately two thirds of injuries in this study were classified as new injuries (62%) compared to recurring injuries (38%). These findings could not be compared with other UK military studies as most reports do not differentiate between new and recurring injuries, but usually classify all as new injuries. Previous injury increases the risk of sustaining a further injury in the military environment [15], [16]. In developing an injury mitigation strategy, a better understanding of recuring injuries is required, as this can provide a focus for intervention. Recurring injuries may develop due to individuals not seeking medical treatment for an injury in the first instance, or incomplete injury management pathways leading to a return to duties before full recovery.

The majority of musculoskeletal injuries occurred during ski-related (61%) and load carriage (10%) activities. The shoulder, knee and lower back were the most common injury locations in this deployed cohort. When compared to published studies in trained personnel, the knee and lower back are recognised as most frequent injury locations [17]. Surveys of occupational groups working in cold weather environments have similarly identified the lower back as a common injury location [18], [19]. Shoulder injures do not occur as frequently as lower limb injuries within trained military populations. However, it does appear to be unique to this training environment; Howes et al [3] similarly identified the anterior shoulder as a common injury location during Cold Weather Warfare training. Although specific mechanisms of injury were not analysed as part of this study, anecdotal evidence from the Forward Rehabilitation Team suggest that shoulder injuries tended to occur during high velocity falls. Lower back injuries occurred due to falls and/or

the act of load carriage whilst in the cold environment. Knee injuries were due to forced rotation of the knee joint with valgus as the body rotated on fixed skis. Determining specific mechanisms of injury could be an area for investigation in future studies.

Efficacy of the Forward Rehabilitation Team was assessed through use of patient reported outcomes (i.e. FAA and MSK-HQ). On admission to the Forward Rehabilitation Team, 23% (n=31) of patients declared they were fit for their trade (FAA1 and FAA2), this increased to 74% (n 91) following intervention. Seventy patients completed a MSK-HQ on admission, but only 38 forms were completed on discharge. A review of outcomes of the 38 complete data sets demonstrated that 28 patients had a minimally important clinical difference. It is recognised that incomplete data sets provide a challenge when determining efficacy of the intervention received. However, it is noted that 17 personnel who did complete a discharge form were only seen once by the rehabilitation team. When comparing the two outcome measures, the FAA score may be more relevant for a deployed environment where patients were usually quickly ahead of a decision being made with respect to remaining in situ or being aeromedically evacuated for UK-based rehabilitation.

The FAA score provided an indication of ability to cover all aspects of the military role and wider associated duties. The MSK-HQ provided a measure of musculoskeletal health and quality [12]. However, it requires reporting on symptoms experienced ‘over the last two weeks’, which may present challenges when assessing and discharging patients over a short time interval. Nevertheless, clinical improvements in symptoms were identified in the present study’s small sample size. When reviewed in conjunction with FAA scores, this demonstrated the effectiveness of the Forward Rehabilitation Team to return patients to military duty. The use and appropriate completion of outcome measures warrants further study.

Another area for consideration relative to efficacy of forward rehabilitation is the financial cost burden of musculoskeletal injury. Of the 136 patients seen in location, seventeen were aeromedically evacuated to the UK. It is unknown whether this number would be higher without the presence of the Forward Rehabilitation Team, as there are no comparator studies. Estimated costs for aeromedical evacuations from Norway (assuming scheduled flight but the need for additional seat space) is *circa* £20k per patient. The RAF Air Ambulance for severely injured patients cost *circa* £300k/hour [20]. Efforts to reduce this cost and, where possible, retain key enabling personnel in location will benefit the individual and wider organisation – and therefore should be further explored.

The purpose of this study was to determine musculoskeletal injury rates and outcomes during Cold Weather Warfare training to inform appropriate injury mitigation strategies. It was evident that the highest number of injuries were related to skiing activity, followed by load carriage. It is unknown whether this is due to skiing competency, general conditioning or additional environmental factors. Findings by Howes et al [3] suggest that skiing competency is associated with injury risk; the highest injury rates accompanied the rapid transition from non-skier to skiing with a bergen and weapon. It is also widely accepted that poor physical fitness is associated with increased risk of musculoskeletal injury [21]. This study did not seek to measure ski proficiency or physical fitness. However, these are further areas to consider prior to deployment to determine effects on injury in this specific population.

Environmental factors, hydration, sleep deficit and sub-optimal nutrition might separately or in combination increase injury occurrence [22], [24]. Military training exercises can involve interrupted sleep, limited food choice and periods where dehydration occurs due to exertional sweat and respiratory water losses. Anecdotally, it was recognised in this study that environmental factors might also have played a role in the development of musculoskeletal injury, but further work is needed in this area. For example, it was noted that personnel were only issued the standard 1 L water flask for maintaining hydration status. Arduous physical work can be associated with fluid losses in excess of 2 L.h [22]. Thus, unless there were purposeful opportunities to replenish the flask scheduled throughout the day, and/ or an additional flask is provided, there would be a likelihood of dehydration.

4.1 Strengths and Limitations to the Study

Whilst this is the first study to describe the injury rate sustained during Cold Weather Warfare training and a deployment to Norway, there are acknowledged limitations. The strength of the study is that all patients requiring intervention presented to one centre, which ensured a consistent interpretation and data capture. All data extracted and analysed from electronic medical records were reliant on the accuracy and precision of patient recall with regards to history of the injury, and the ability of clinicians to record medical information accurately and consistently. The injury surveillance activity focused upon reported injuries, which may not provide the full clinical picture of the injury profile within the units, as some personnel may choose not to report injuries. Whilst the course element in which injured personnel were participating was ascertained; it was not possible to control for the environmental factors that made some courses harder than others. Likewise, it was not possible to ascertain the pre-deployment fitness of personnel, which is an acknowledged important risk factor for musculoskeletal injury. It has been demonstrated that some units had a higher injury rate than others; this reflects the activities those units were undertaking, with some units having more people camp-based for the duration of the winter deployment. These factors could lead to an under-estimation of injury prevalence. Future studies should therefore investigate injury rate of courses partitioned from other winter deployment activities. Data collection for the survey ceased at the end of the winter deployment; some patients will have continued their care on returning to the UK, such that the final injury outcome data for all patients are incomplete. This is an area that therefore requires further attention with respect to assessing the long-term burden of Cold Weather deployments for UK Defence.

5.0 CONCLUSIONS

In conclusion, this is the first study that reports the epidemiology of musculoskeletal injury related to Cold Weather Warfare training in Norway. It is evident from the findings that Service personnel are more likely to present with new, sudden onset injuries that are attributable to ski-related activity. The most frequent location of injury was the knee, shoulder and lower back. The efficacy of forward rehabilitation in an exercise environment has been demonstrated through the maintenance of injured personnel in location. Further areas for research to inform mitigation strategies should include skiing competency, general conditioning and the effect of environmental factors including sleep, nutrition and hydration.

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