Musculoskeletal Complaint Epidemiology in Australian Special Operation Forces Trainees

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ABSTRACT

Introduction:

Elite military trainees are burdened by high numbers of musculoskeletal (MSK) injuries and are a priority military population for injury prevention. This research aims to describe the MSK complaint epidemiology of trainees undertaking special forces (SF) training in the Australian Defence Force (ADF). One barrier to accurate injury surveillance in military populations is that traditional surveillance methods rely on personnel engaging with the military healthcare system to collect injury data. This approach is likely to underestimate the injury burden as it is known that many military personnel, particularly trainees, avoid reporting their injuries because of various motives. Subsequently, the insights from surveillance systems may underestimate the injury burden and limit the ability to inform prevention requirements. This research aims to actively seek MSK complaint information directly from trainees in a sensitive manner to mediate injury-reporting behaviors.

Materials and Methods:

This descriptive epidemiology study included two consecutive cohorts of ADF SF trainees from 2019 to 2021. Musculoskeletal data items and their respective recording methods were based on international sports injury surveillance guidelines and adapted to a military context. Our case definition encompassed all injuries or physical discomforts as recordable cases. A unit-embedded physiotherapist retrospectively collected MSK complaint data from selection courses and collected prospective data over the training continuum. Data collection processes were external to the military health care system to mediate reporting avoidance and encourage injury reporting. Injury proportions, complaint incidence rates, and incidence rate ratios were calculated and compared between training courses and cohorts.

Results:

In total, 334 MSK complaints were reported by 103 trainees (90.4%), with a complaint incidence rate of 58.9 per 1,000 training weeks (95% CI, 53.0-65.5). Of these MSK complaints, 6.4% ($n = 22$) resulted in time loss from work. The lumbar spine (20.6%, $n = 71$) and the knee (18.9%, $n = 65$) were the most frequently affected body parts. Most of the MSK complaints were reported during selection courses (41.9%), followed by field survival and team tactics (23.0%) and urban operations courses (21.9%). Physical training accounted for 16.5% of complaints. Fast-roping training was associated with more severe MSK complaints.

Conclusions:

Musculoskeletal complaints are highly prevalent in ADF SF trainees. Complaints are more frequently reported in selection and qualification training courses than in physical training. These activities are priorities for focused research to understand injury circumstances in ADF elite training programs to inform injury prevention strategies. A strength of our study is the data collection methods which have provided greater MSK complaint information than past research; however, much work remains in conducting consistent and accurate surveillance. Another strength is the use of an embedded physiotherapist to overcome injury-reporting avoidance. Embedded health professionals are recommended as continued practice for ongoing surveillance and early intervention.

INTRODUCTION

Trainees undergoing military training are a priority population for injury prevention in the military because of consistently reported higher injury frequency than fully qualified soldiers.[1]

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In the Australian Defence Force (ADF), candidates applying to undertake special forces (SF) training are selected based on their resilience in extreme physical and psychological circumstances. Successfully selected candidates proceed to a 12-month training program to become qualified in advanced operational tactics, such as parachuting, amphibious operations, and urban combat. Paradoxically, the selection processes and qualification training of these personnel can also cause injury. Past research has reported that up to one in four trainees withdraws from elite military training because of injury,[2] reducing graduate numbers and collectively impacting military capability. Furthermore, up to 68% of trainees will sustain an injury during specialist training.[2] Injuries during training are of additional concern as a prior injury is a risk factor for future injury in the military.[3] Thus, injuries sustained early in a trainee's career may have further consequences.

Preventative health frameworks conceptualize sequential steps to minimize injuries.[4,5] Injury surveillance, the process of collecting, analyzing, and interpreting injury data,[6] is the first step of these frameworks to describe the injury problem and identify causes. Relevant stakeholders integral to injury prevention, such as health professionals and military commanders, can use surveillance insights to inform, prioritize, and evaluate prevention strategies. Surveillance of milder musculoskeletal (MSK) complaints and their precursors to more severe injuries has been investigated in sports and military contexts,[7,8] indicating that milder physical complaints can identify those at imminent risk of developing an injury requiring an absence from work or sport. This relationship is logical when considering the natural history of overuse injury types, where symptoms occur gradually following repetitive activity. Thus, insights from milder ailments could inform early interventions to minimize their progression to more severe injury. These intervention strategies are likely beneficial in a military context where overuse injuries are more common than acute traumatic injuries.[9]

Musculoskeletal injury surveillance research investigating injuries in SF populations is predominately restricted to the U.S. military and is often limited by missing or inconsistent data and information.[1,10] Of the available research, evidence suggests that SF trainees appear to be at greater injury risk compared to qualified personnel.[11] Most SF trainees' injuries are related to physical training (PT) and occur during running or heavy lifting.[1] Similar to other military populations, the lower limb and spine appear to be the most common body parts affected.[1] The most common injury types affecting SF populations are similar to sporting populations, with sprains and strains and non-specific pain as the most common injury diagnoses.[1] Although this evidence may help direct future research and prevention initiatives in the U.S. SF populations, these insights cannot be confidently applied to an Australian setting. There is a void in research investigating MSK complaints epidemiology in Australian SF populations. Subsequently, little evidence exists to inform injury prevention in Australian SF.

Further to limited Australian research and injury data limitations, one barrier to accurate health surveillance in military populations is that traditional surveillance methods rely on personnel engaging with the health care system to collect injury data. Traditional surveillance approaches are likely to underestimate the injury burden as many injured personnel avoid seeking medical help because of various motives.[12] Past literature indicates that approximately two-thirds of injuries that trainees sustain go unreported to the military health care system, with fear of not graduating as the most common reason for trainee health care avoidance.[13] For this reason, active surveillance, a process whereby injury information is actively requested from individuals, is recommended to overcome reporting barriers and gain insights into the true injury burden extent.[10]

This research aims to describe the MSK complaint epidemiology of Australian SF trainees by actively seeking complaint information directly from trainees in a sensitive manner to mediate injury-reporting behaviors. The secondary aims are to translate these findings into evidence-informed prevention recommendations.

METHODS

Musculoskeletal complaints were observed in trainees over two consecutive selection courses and SF training programs from October 2019 to October 2021 in a prospective cohort study. The Department of Defence and Veteran Affairs Human Research Ethics Committee granted ethical approval for this study (protocol number 266-20).

Participants

Participants were ADF personnel undertaking the annual 3-week selection course to qualify for SF qualification training. Successful candidates proceeding to SF training continued to be observed over the following 12-month training period. Unsuccessful candidates were excluded from the study. All participants provided written consent before partaking.

Data Collection

Data collection commenced upon trainees' successful selection into the SF training program and in alignment with the commencement and completion of the two 12-month training cohorts. For the purpose of this study, our complaints case definition considered all injuries or physical discomforts as recordable cases, including complaints not leading to medical attention or restricted duty.[14] Complaint data from the selection course were collected retrospectively from successful candidates at the end of the selection course. Complaint data during the subsequent training continuum were collected prospectively. Data variables related to demographic

and health information were collected and recorded as listed in Supplementary File S1. Musculoskeletal data items and recording methods were based on international sports injury surveillance guidelines[15] and adapted to a military context. Injury type was categorized using the Orchard Sports Injury and Illness Classification System, Version 13.1.[16] Sport surveillance methods were chosen because similar injuries occur between military and sporting populations[17]; therefore, such methods could apply to a military context.

Complaint data were collected during physiotherapy consultations over the training period by a unit-embedded physiotherapist. Additionally, the Oslo Sports Trauma Research Center Questionnaire on Health Problems (OSTRC-H),[18] a self-report health questionnaire commonly used to monitor injury in sports, was used to encourage reporting. The questionnaire was distributed to participants approximately quarterly, beginning upon selection course completion, and before the training continuum commenced. Questionnaire responses indicating a complaint was present were used as a prompt to initiate a physiotherapy consultation where further data points were collected. These data collection processes were external to the military health care system to encourage reporting.[19,20] The embedded physiotherapist could provide early intervention management, such as education, or refer to the military health care system where clinically indicated.

In the absence of recommended military-specific activity categorization codes to monitor injury determinants, activity categories were created by the research team. Activity codes were developed to broadly reflect qualification training, PT, or the selection course. Subcategories were allocated within qualification training aligned with the training curriculum, such as fast-roping or parachuting courses, to provide greater detail on military activities' risk. Physical training was included as a separate activity category. A category assigned "other" was created to signify complaints where the trainee was unsure of the activity or if the complaint was non-work related.

The Military Severity Rating-1.0 (MSR-1.0) scale was designed and adapted from the participation question of the OSTRC-H[18] as a clinician data collection tool to measure occupational consequences relevant to a military context (Fig. 1). Specifically, this scale categorized the severity of occupational outcomes, such as if the injury resulted in reduced performance, required a period of unfit duty, or medical employment reclassification, with the latter indicating greater injury severity. In the ADF, a medical officer assigns military personnel a permanent medical employment classification based on whether their health status allows an individual to be deployable, deployable with restrictions, or not deployable. Based on clinical assessment, injured personnel may be given a period of temporary restricted duty without changing this classification, as represented by level three of the MSR-1.0 scale. Temporary restrictions are used for conditions where recovery is expected within 28 days.

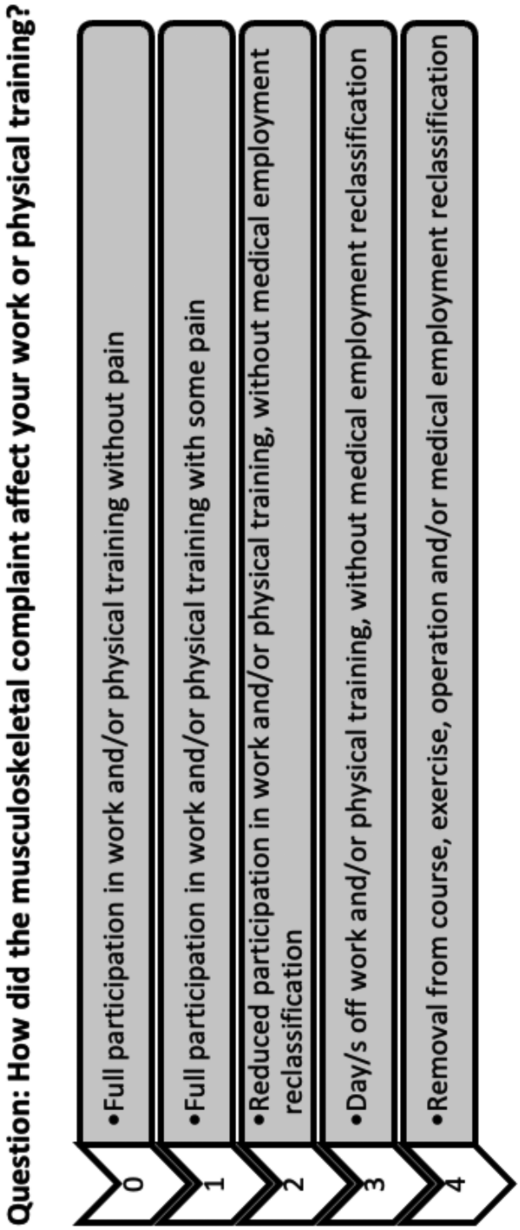

FIGURE 1. The Military Severity Rating-1.0 scale.

Individuals requiring greater recovery time are reclassified as non-deployable, as represented by level four of the MSR-1.0 scale.

Data Analysis

Descriptive data analysis was conducted for complaints in each training cohort and the total surveillance period. Because of the practical limitations of recording granular training exposure in terms of duration and intensity, a pragmatic approach that detailed each trainee's weekly training course was used to measure activity exposure. Right censoring was undertaken when a trainee was removed from the training program (e.g., course failure). Complaint incidence rates

(CIRs) were calculated using the number of complaints/sum of participant weeks × 1,000. Poisson 95% CIs for CIRs were calculated. Complaint incidence rates between training periods and age groups were compared using generalized linear mixed models fitted with negative binomial regression to calculate incidence rate ratios (IRRs) and their associated 95% CIs. Statistical significance of incident rate ratios were determined when the 95% CI did not include 1.0. The complaint burden was calculated using mean severity (MSR scale rating) × CIR. A complaint risk (burden) matrix was plotted where the mean complaint severity was plotted against the CIR for the complaints with the largest burden.[21] All statistical analyses were performed using Stata (Stata/SE 16.1, StataCorp, USA).

RESULTS

All 114 eligible trainees consented to participate, with five participants repeating qualification training twice in the study period, thus totaling 119 trainees across the two cohorts. Participants had a mean age of 28.0 years (±3.9), ranging between 19 and over 35 years (Table I). Sex results are not reported because of the small number of women in the study and the necessity to preserve individual privacy. In total, 103 trainees (90.4%) experienced at least one MSK complaint, with a total of 344 MSK complaints sustained across the study period. The CIR was 58.9 (95% CI, 53.0-65.5) across the two training periods, with no significant difference observed between the two cohorts (IRR = 1.10, 95% CI, 0.82-1.46). Of the complaints, 6.4% ($n = 22$) resulted in time loss from work, as indicated by summing levels three and four on the MSR-1.0 scale. There was no statistically significant difference in the IRR across the age groups (Table I). Most MSK complaints were new (66.3%, $n = 228$), and one-third were subsequent complaints (33.7%, $n = 116$), such as an injury recurrence. The lumbar spine (20.6%, $n = 71$), knee (18.9%, $n = 65$), and thoracic spine (10.5%, $n = 36$) were the most frequently affected body parts (Supplementary File S2). The most frequent complaint types were nonspecific lumbar, thoracic, and knee pain (Supplementary File S2).

Table II compares the complaint frequency between SF selection courses, qualification courses, and PT. Collectively, greater complaint frequency was reported for training courses (44.7%, $n = 154$) than both selection courses (32.3%, $n = 111$) or PT (16.5%, $n = 57$) (Table II). The selection course, field survival and team tactics, and the urban operations courses were the top three courses most associated with complaints, as demonstrated by the highest CIR, 381.4 (95% CI, 316.7-459.4), 72.4 (95% CI, 56.3-93.0),

TABLE I. The Demographics of Trainees and MSK Complaints Distribution per Surveillance Year

	2019-2020	2020-2021	Total
Demographics			
Participants[a], *n*	61	58	119
Age, mean (SD)	27.3 (3.8)	28.7 (3.9)	28.0 (3.9)
Incidence			
Complaints, *n*	164	180	344
Range of complaints, *n*	0-9	0-9	0-9
MSR-1.0 scale, *n* (%)			
0	30 (18.3)	18 (10.0)	48 (14.9)
1	66 (40.2)	109 (60.6)	175 (50.9)
2	50 (30.5)	49 (27.2)	99 (28.8)
3	7 (4.3)	2 (1.1)	9 (2.6)
4	11 (6.7)	2 (1.1)	13 (3.8)
Trainees with a complaint, *n* (%)	53 (86.9)	54 (93.1)	103 (90.4)
Mean number of complaints (SD)	2.7 (2.2)	3.1 (2.2)	3.0 (2.2)
CIR (95% CI)[b]	55.9 (48.0-65.2)	61.9 (53.5-71.7)	58.9 (53.0-65.5)
CIR (95% CI)[b] by the age group			
19-24	54.2 (38.1-77.1)	76.9 (51.6-114.8)	62.2 (47.8-81.0)
25-29	55.4 (45.1-68.0)	61.6 (50.3-75.4)	58.4 (50.6-67.4)
30-34	60.7 (44.7-82.5)	60.5 (45.8-79.8)	60.6 (49.3-74.4)
≥35	23.8 (3.4-169.0)	49.8 (28.3-87.7)	45.9 (26.7-79.1)
IRR by the age group (95% CI)			
19-24			1.00
25-29			0.93 (0.62-1.40)
30-34			1.00 (0.64-1.60)
>35			0.69 (0.32-1.52)
Subsequent complaints, *n* (%)			
Initial index complaints	118 (72.0)	110 (61.1)	228 (66.3)
Subsequent complaints	46 (28.0)	70 (38.9)	116 (33.7)

Abbreviations: CIR, complaint incidence rate; IRR, incidence rate ratio; MSK, musculoskeletal; MSR, Military Severity Rating.
[a]The 2021 cohort includes five participants repeating qualification training from the 2019 cohort.
[b]CIR per 1,000 weeks.

TABLE II. Complaint Frequency by Selection Course, Qualification Training Course, and PT

Activity	2019-2020		2020-2021		Total	
	n	%	*n*	%	*n*	%
Selection	48	29.3	63	35.0	111	32.3
Military training	64	39.0	90	50.0	154	44.8
PT	36	21.9	21	11.7	57	16.5
Other	16	9.8	6	3.3	22	6.4
Total	164	100.0	180	100.0	344	100.0

Abbreviation: PT, physical training.

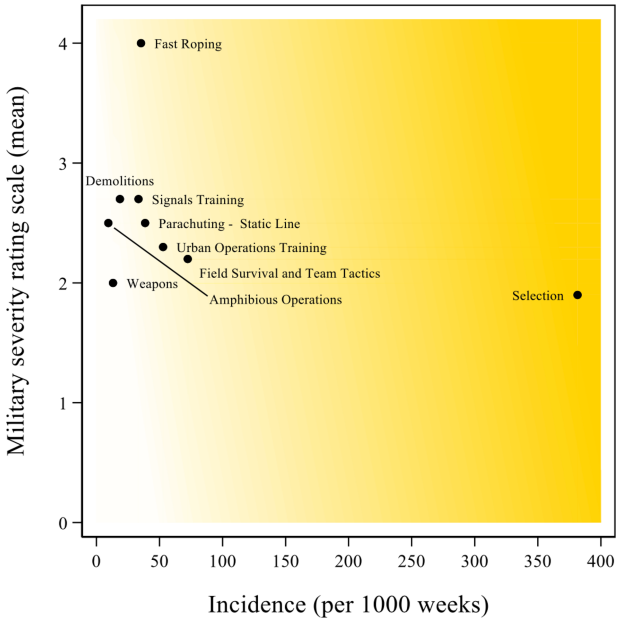

FIGURE 2. The complaints burden of each training course as demonstrated by complaints severity in relation to the complaints incident rate.

and 52.8 (95% CI, 40.8-68.3) per 1,000 weeks, respectively (Supplementary File S3). Figure 2 demonstrates the complaint burden of each qualification course and selection, highlighting that the fast-roping course had the greatest complaint severity, followed by the demolitions and signal training courses.

DISCUSSION

Musculoskeletal complaints were highly prevalent across the two SF training cohorts, with more than 90% of trainees reporting at least one complaint. Of these complaints, 6.4% resulted in some form of time loss from work. The knee and lumbar spine were the most frequent body parts affected, consistent with previous research.[1] The selection course was the activity with the highest MSK complaint rate, having a 5-fold greater rate than any other activity. Fast-roping was associated with the most severe injuries, resulting in removal from training or medical reclassification. Musculoskeletal complaints occurred less frequently in PT than in qualification training courses.

Our MSK CIR is higher than other international militaries investigating SF trainees; however, the time-loss complaints proportion resulting in time loss is less.[1,11] This difference is potentially because of the selection and training programs or alternative study methods. Our surveillance methods are likely to increase complaint counts for several reasons. First, we used a more inclusive injury case definition whereby all physical discomforts were included compared to past research, which has used more restrictive case definitions, such as injuries requiring medical attention or time loss.[1] Second, our study design actively pursued information from trainees without relying on personnel attending health facilities. Subsequently, we are more likely to detect minor ailments that do not result in personnel seeking medical help and, therefore, are not represented in health care system datasets. Although injury case definition use and data collection methods can account for some result variations with past literature, our CIR results remain higher than other studies using equivalent definitions and similar self-report surveys.[22]

Our MSK CIR may be higher than in previous reports as trainees were given the option to visit the embedded military physiotherapist without directly attending a military health facility. Past research has indicated that elite military personnel underreport health issues for various reasons, such as difficulties developing therapeutic relationships with clinicians who do not share military understandings.[20] Research in SF populations has also uncovered a desire for embedded health professionals in a perceived facilitatory than restrictive capacity.[19] In the ADF, the health facilities are predominately staffed by civilian clinicians. An embedded military physiotherapist was intentionally used to mediate the aforementioned health-seeking deterrents, which may account for our higher complaint rate. The embedded physiotherapist may also account for the lower proportion of time loss from work. As trainees received help early, the embedded physiotherapist could provide early intervention, potentially stopping complaint progression into one resulting in time loss.

Unlike previous military injury research demonstrating greater injury risk in general military populations for those over the age of 35 years,[3] we found no greater injury risk associated with any age group. This result difference could be because of more senior SF trainees having greater physical conditioning for military activities or potentially because of the reporting behaviors of older personnel. Some international militaries have specific SF eligibility criteria that candidates must satisfy to apply and commence SF training, such as the maximum age restrictions.[23] Given that older age is an established injury risk factor in the military,[3] such eligibility criteria may be protective. The ADF has no maximum age restriction to undertake SF training.[24] Although our results suggest no greater injury risk with increasing age, longitudinal

studies are recommended to monitor age, complaint risk, and medical discharge over career duration. Such information can help determine the requirement for age eligibility restrictions to protect personnel health while maximizing the organizational benefits by optimizing the retention of highly specialized soldiers.

Contrary to previous literature, which indicates that PT is the most common activity associated with SF trainee injuries,[1] our study demonstrated higher complaints frequency and severity with qualification courses. These result differences could be attributed to our surveillance methods, differences in the conduct of training programs between nations, or world events at the time. Previous research describing injury determinants in SF populations has been limited to secondary data collection methods where activity information is often missing or inadequately detailed, making comparison difficult.[10] The primary data collection methods in this study allowed more detailed activity information to be recorded than in past literature, which may account for some result variability. Furthermore, it is difficult to confidently compare our results with past literature without detail and activity exposure information from other international military SF training and PT programs. Another consideration is that the result difference and overall reduced number of PT-related injuries may be attributable to the COVID-19 pandemic. During the pandemic, all military qualification training proceeded as an essential activity, whereas social distancing requirements limited PT. Of note, approximately half the number of PT-related complaints occurred in the 2020-2021 cohort compared to the previous cohort, which was impacted by the pandemic for approximately half the time. Because of the pandemic-imposed social distancing restrictions, personnel conducted individual PT than group-based PT and had reduced gymnasium accessibility. However, we did not collect PT exposure data, limiting the ability to compare accurately. Continuous surveillance research in future training cohorts not impacted by COVID-19 is required to monitor activities associated with injury.

The selection course had the highest MSK CIR throughout the entire continuum, five times that of any other activity. Selection courses are deliberately challenging to select the most robust soldiers to undertake SF training. In this instance, a certain level of injury risk is accepted by military commanders. The "acceptable" injury thresholds should be discussed and defined with commanders so that the subsequent selection courses can be refined to ensure complaints, particularly severe injuries, are not occurring at greater rates than what is considered absolutely necessary. Mitigating training injuries is important as past complaints are a risk factor for future injuries[3,8] and may lead to further consequences during training and once qualified.

Fast-roping, a skill used to descend a thick rope usually from helicopters, was associated with complaints resulting in the most severe occupational impact, requiring course removal or medical reclassification. Further investigations into fast-roping complaint circumstances and injury etiology, such as injury mechanisms, are necessary to inform prevention strategies. It is challenging to know which prevention strategies are indicated without this information. Such prevention strategies may include greater landing skill refinement on softer surfaces before progressing to hard surfaces, more daytime practice before moving to night-time tactics, or improving equipment, such as glove grip.

STRENGTHS AND LIMITATIONS

A study strength is that our study design and surveillance methods align with the recommended sports methods[15] to guide a structured approach. Another strength is our primary data collection methods that enabled us to collect greater activity and exposure information than in past research. However, despite these efforts, our data have limitations, such as a lack of detailed complaint mechanism information. The lack of injury mechanism information is a common limitation in military injury research and a priority to rectify for future effective surveillance.[10] Another consideration is the use of the MSR-1.0 scale to measure the occupational impact of injury, making the comparison of injury consequences and severity challenging as it is a different approach from past research. Although the MSR-1.0 scale does not measure the exact number of time-loss days, making it difficult to compare with other literature, one advantage is the scale that can quantify the number of injuries requiring time loss and the number of personnel medically reclassified. Since finalizing our data collection, a consensus providing guidelines for injury surveillance in SF populations has been published.[10] Our future surveillance methods will be refined according to these guidelines to promote a consistent and accurate approach to surveillance.

Another study limitation is that selection course data were collected retrospectively after the 3-week course and restricted to successful candidates, restricting comparisons between Australian and international SF selection courses. Unsuccessful candidates are highly likely to have sustained MSK complaints. Subsequently, our results are subjected to survivor bias and underestimate the selection course complaint burden. As the physiotherapist was newly embedded within the SF unit, data collection primarily focused on MSK complaints during the training curriculum. Our future surveillance methods will aim to include all selection course participants to understand the broader health effects and the impacts of these soldiers returning to parent units in conventional forces.

Despite our study methods, it is likely that MSK complaint concealment continued among trainees to some extent because of the fear of unwanted career events. A strength of our research is that we used an embedded military physiotherapist to attempt to overcome this barrier, and we recommend this as continued practice for ongoing surveillance. Establishing rapport with personnel is necessary for accurate surveillance and to encourage trainees to seek health care when

needed.[20] Further to this practice, future injury surveillance could include anonymous reporting methods if embedding military clinicians is not possible and if reporting behaviors are felt to impede data collection.

CONCLUSION

Musculoskeletal complaints are prevalent in Australian SF trainees. Our study design and data collection methods have provided greater MSK complaint information than in past research; however, much work remains in conducting consistent and accurate surveillance. Selection and military training courses appear to be associated with higher MSK complaints and injury severity than PT in Australian SF cohorts. These activities are a priority for further investigation to understand complaint and injury circumstances in elite training programs to inform injury prevention strategies in Australian SF.

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SUPPLEMENTARY MATERIAL

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicting interests.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

CLINICAL TRIAL REGISTRATION

None declared.

INSTITUTIONAL REVIEW BOARD (HUMAN SUBJECTS)

The DoD and Veteran Affairs Human Research Ethics Committee granted ethical approval for this study (protocol number 266-20).

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC)

Not applicable.

INSTITUTIONAL CLEARANCE

Institutional clearance approved by the Australian DoD.

INDIVIDUAL AUTHOR CONTRIBUTION STATEMENT

L.W., A.F., L.T., and M.D. designed the project. L.W. conducted all data collection. L.T. led the data analysis. J.S. led data interpretation and drafting of the manuscript with input from all authors. All authors approve the submitted version and are accountable for the accuracy and integrity of the work.

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