Prevalence, Anatomical Patterns, Functional Consequences, and Treatment Approaches for Musculoskeletal Injuries Among Military Trainees in Saudi Arabia

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Abstract
Background: Musculoskeletal injuries (MSKIs) are a major health problem in military training cohorts worldwide but there are limited epidemiological data from Middle Eastern military populations. The purpose of this study was to identify the prevalence, anatomical distribution, functional effects, and treatment options for MSKIs among military trainees in Saudi Arabia.
Methods: A cross sectional study was done on 351 male military trainees at King Fahad Security College, Riyadh, Saudi Arabia. A structured self-administered questionnaire was used to obtain data on 12-month and 7-day prevalence of pain across nine body regions, mechanism of injury, functional impact and treatment modalities. Descriptive statistics and chi-square were conducted.
Results: The 12-month prevalence of MSKI was 57.0% and most affected areas included the lower back (44.7%) and knees (31.6%). The most common mechanism of injury was running

(47.0%) and military drills (43.5%). The functional impact was significant, affecting 33.0% of people. Pharmacological management was common (29.1% oral NSAIDs) but physiotherapy was only used to a limited extent (4.6%) and 17.7% reported a persistent pain. The significant associations were with obesity (92.3% prevalence, $p<0.001$), training frequency ($p=0.020$), education level ($p=0.006$), and previous injury history ($p=0.048$). **Conclusion:** This is the first comprehensive military MSKI study in Saudi Arabia, which demonstrates a high injury burden, mainly affecting the lower back and knees, and also shows a significant burden on function and unmet needs for rehabilitation provision. Improved access to physiotherapy as well as better injury surveillance and a targeted prevention strategy to address modifiable risk factors are urgently needed to optimise trainee health and operational readiness.

Keywords: Musculoskeletal injuries, military trainees, prevalence, Saudi Arabia, lower back pain, knee injuries, functional impact

INTRODUCTION

MSKIs are one of the largest challenges to the health and performance of military training institutions globally. These injuries represent a wide range of acute sprains and strains, chronic overuse syndromes and stress fractures and are a significant source of morbidity, restricted duty and medical discharge in the military [1, 2]. Military training demands are extremely high, involving extensive physical activity, high volume and repetition, which places the recruits at high risk of injury, especially during initial entry training (IET) [3]. The basic military training is usually designed to include daily physical conditioning, running, carrying and loaded marching, obstacle courses, tactical drills, etc., all of which are designed to impose significant mechanical stresses on the musculoskeletal system [4].

The burden of MSKIs in military recruits has been well established worldwide. The prevalence of recruits that required medical attention injuries was 22.8%, and 31.4% required time loss injuries [5]. The distribution of MSKIs is consistent and always involves the lower extremities and lumbar spine, and most commonly the knee, ankle and lower back [6, 7]. Lower limb injuries make up about 80% of all MSKIs in military training populations, reflecting the biomechanical demands of running, marching with heavy loads and repetitive physical conditioning exercises [6].

Although numerous epidemiological studies have been conducted in military populations from North America, Europe and Asia, there is little epidemiological data available for military trainees in the Middle East region, especially in Saudi Arabia. In Saudi Arabia, basic military training takes 12 weeks and consists of daily military training programmes that may last for around 12 to 15 hours, which is similar to the basic military training programmes in the United Kingdom and the United States. This study will help to overcome this critical knowledge gap by identifying the prevalence and nature of musculoskeletal injuries of military trainees at KFSC.

METHODOLOGY

Study Design

The study was an epidemiological cross-sectional descriptive study of military trainees at King Fahad security College (KFSC) in Riyadh, Saudi Arabia.

Study Setting
The study was carried out at King Fahad Security College (KFSC) which is the best military training institution in Riyadh city, Saudi Arabia. The basic military training programme at KFSC duration is 12 weeks and daily training at KFSC lasts about 12-15 hrs which involves physical fitness training, military drills, running, obstacle courses, load carriage training etc.

Study Population and Sampling
The subjects were all male military trainees attending KFSC during the period of the study. Census sampling method was used where all the eligible trainees were invited to participate.
Inclusion Criteria:
•. Male military students at KFSC for the study period.
• Retrieved trainees who consented to be trained.
• Trainees able to complete the self-administered questionnaire.
Exclusion Criteria:
•Absence of Trainee(s) from data collection (medical leave, official duty, vacation).
•Those who opted not to take part.
• Inability of trainees to fill out the questionnaire because of language barriers.
The questionnaire was completed and analysed by a total of 351 trainees.

Data Collection Tool
A self-administered questionnaire, developed in line with the study, was used to gather data. The questionnaire was first tested with 20 trainees to test its clarity and feasibility. The questionnaire consisted of the following sections:
1. Demographic and Baseline Information: Age, height, weight, education level, smoking status, training frequency.
2. Injury History and Mechanisms: injury occurrence, mechanism of injury (running, military drills, impact/collision, load carriage, prolonged walking, sports activities) and rest period taken.
3. Anatomical Distribution of Pain (Over 12 Months): Number of pain locations in nine body areas (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, ankles/feet).
5. Anatomical Distribution of Pain (Last 7 Days): Pain in the same nine body areas in the last week.
Functional impact: Restriction in doing regular work and inability to do regular work.
6. Pain Management and Treatment: Topical analgesics, physiotherapy, exercise compliance, shock wave therapy, persistent pain, oral painkillers and muscle relaxants.
7. Chronic Diseases and Pre-existing Conditions: Chronic diseases or previous injuries.

Variables and Scoring
This study used a comprehensive collection of musculoskeletal injury primary outcome and independent variables to describe the musculoskeletal injury burden and associated factors among military trainees. The primary outcome measures were prevalence of MSKI, and defined as the percentage of participants with at least one reported site of pain over the past 12 months within the nine body regions measured, as well as the number of participants who had no pain in their nine body regions. The severity of pain and the distribution of pain were measured with the following composites: 12-month Pain Score (0–9), calculated as the sum of

positive responses across all 9 body regions; 7-day Pain Score (0–9), calculated as the sum of positive responses during the past week; and Musculoskeletal Burden Index (0–18), calculated as the sum of the 12-month Pain Score and 7-day Pain Score, that was then categorised into levels of Burden (Low: 0–4, Moderate: 5–9, High: 10–14, Very High: 15–18). Functional impact was measured using the Functional Impact Score (ranging from 0 to 3) where questions about work limitation were answered with either a No or Low impact (0–1), Moderate impact (2), or a High impact (3). Demographic and lifestyle factors measured included: Body Mass Index (BMI) calculated from self-reported height and weight, and grouped according to World Health Organization criteria as Underweight (<18.5 kg/m²), Normal (18.5 – 24.9 kg/m²), Overweight (25 – 29.9 kg/m²), and Obese (≥30 kg/m²); training frequency per week (1-2, 3-4, 5-7 times, and no sport participation); smoking status (non-smoker, traditional cigarette smoker, electronic cigarette smoker, and nicotine pouch user); and education level (University, Preparatory, Final/Secondary, and Intermediate).

Data Collection Procedure

The survey was conducted in Arabic, during drill-free times, as part of the training. Research assistants were on hand to explain questions. Completed questionnaires were checked for completeness and kept in a secure location. All data was entered into a password guarded electronic database.

Statistical Analysis

IBM SPSS Statistics for Windows (version 26.0) was used for data analysis. All the variables were analysed using descriptive statistics. Continuous variables (age, BMI, pain scores) were presented as mean, standard deviation, median and interquartile range. Frequencies and percentages were used to present categorical variables (education, smoking, training frequency, presence of pain, treatment modalities). Cross-tabulations were employed to explore the relationship between independent variables and prevalence of MSKI.

Ethical Considerations

The study was performed according to the Declaration of Helsinki. Ethical approval was given by the institutional review board. Written informed consent of all the participants was obtained. Data were anonymized and kept in a secure manner for confidentiality.

RESULTS

Table (1) shows that study cohort consisted of 351 male military trainees with a mean age of 25.3 ± 2.8 years (range: 19–31) and a mean BMI of 24.0 ± 3.2 kg/m². The majority had a normal BMI (56.4%), while 33.9% were overweight and 7.4% were obese. Regarding education, 67.8% held a university degree, 22.2% had preparatory education, 6.8% had final/secondary education, and 3.1% had intermediate education. Smoking was reported by 33.3% of the cohort, with nicotine pouches being the most common form (21.4%). In terms of training frequency, 46.4% trained 1–2 times per week, 30.5% trained 3–4 times, 18.8% trained 5–7 times, and 4.3% did not participate in sports. The prevalence of chronic diseases in this cohort was relatively low, with only 4.6% (n=16) reporting any chronic condition. The most commonly reported conditions were asthma (0.6%), diabetes mellitus (0.6%), and psoriasis (0.3%). Additionally, 2.6% (n=9) of trainees reported a history of previous injuries, which may predispose them to recurrent musculoskeletal problems.

Table 1: Demographic Characteristics of the Study Participants

Characteristic	Category	n	%
Age (years)	Mean ± SD	25.3 ± 2.8	–
	Range	19 – 31	–
Height (cm)	Mean ± SD	175.4 ± 5.2	–
	Range	147 – 193	–
Weight (kg)	Mean ± SD	73.8 ± 11.4	–
	Range	53 – 120	–
BMI (kg/m²)	Mean ± SD	24.0 ± 3.2	–
	Underweight (<18.5)	8	2.3%
	Normal (18.5–24.9)	198	56.4%
	Overweight (25–29.9)	119	33.9%
	Obese (≥30)	26	7.4%
Education Level	University	238	67.8%
	Preparatory	78	22.2%
	Final / Secondary	24	6.8%
	Intermediate	11	3.1%
Smoking Status	Non-smoker	234	66.7%
	Traditional cigarettes	23	6.6%
	Electronic cigarettes	19	5.4%
	Nicotine pouches	75	21.4%
Training Frequency	1–2 times/week	163	46.4%
	3–4 times/week	107	30.5%
	5–7 times/week	66	18.8%
	No sports	15	4.3%
Presence of Chronic disease	**Any chronic disease**	16	4.6%
	Asthma	2	0.6%
	Diabetes Mellitus	2	0.6%
	Psoriasis	1	0.3%
	Other / unspecified	11	3.1%
	Previous injuries (self-reported)	9	2.6%

More than half of the trainees (57.0%, n=200) reported at least one musculoskeletal pain site over the previous 12 months. Among those injured, running (47.0%) and military drills (43.5%) were the most frequently cited injury mechanisms, followed by impact/collision (23.5%), additional load carriage (20.5%), prolonged walking (16.5%), and sports activities (14.0%). Notably, 39.5% of injured trainees did not take any rest period following their injury, while only 8.0% took 1–3 days of rest as in table (2).

Table 2: Prevalence and Mechanisms of Musculoskeletal Injuries

Parameter	n	%
Total participants	351	100%
At least one MSKI (12-month pain)	200	**57.0%**

Injury Mechanisms *(multiple responses, denominator = 200 injured)*		
Running	94	47.0%
Military drills	87	43.5%
Impact / collision	47	23.5%
Additional load carriage	41	20.5%
Prolonged walking	33	16.5%
Sports activities	28	14.0%
Rest period taken *(denominator = 200 injured)*		
No rest taken	79	39.5%
1–3 days	16	8.0%
4–14 days	7	3.5%
12–24 hours	6	3.0%
Not specified / other	92	46.0%

Figure (1) shows that, over the preceding 12 months, the lower back was the most commonly affected region, with 157 trainees (44.7%) reporting pain, followed by the knees (31.6%, n=111) and shoulders (27.9%, n=98). Other frequently reported sites included the neck (24.5%), upper back (19.4%), hips/thighs (18.5%), wrists/hands (17.1%), ankles/feet (16.5%), and elbows (13.1%). The total number of positive pain endorsements across all body regions was 749. In the past 7 days, the lower back remained the most prevalent pain site (27.1%, n=95), followed by the knees (19.4%, n=68) and shoulders (16.5%, n=58). Neck pain was reported by 13.1% (n=46), while upper back pain was noted in 12.0% (n=42). The total number of positive pain endorsements in the past week was 445, which is substantially lower than the 12-month total (749), indicating that many injuries are episodic or have partially resolved.

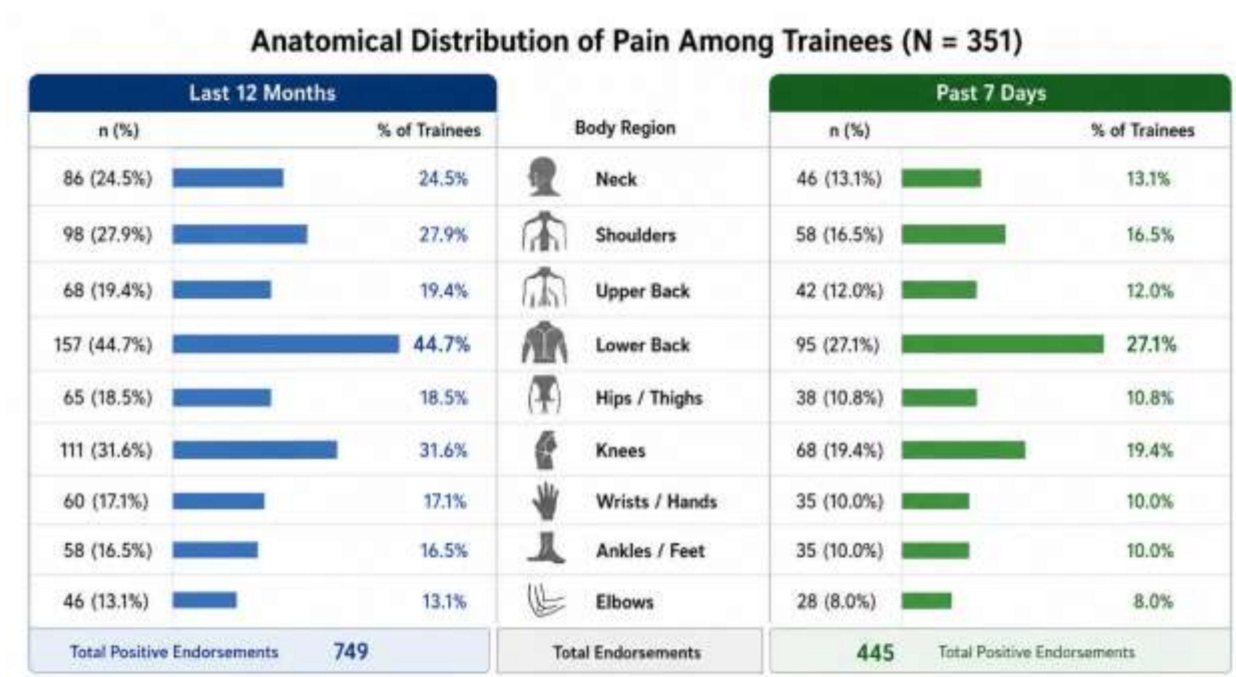

Figure 1: Anatomical distribution of pain among trainees in 12 months vs. 7 days

In table (3). the mean 12-month pain score was 2.13 ± 2.27 out of a maximum of 9, with 43.0% (n=151) reporting no pain at all. For the past 7 days, the mean pain score was 1.27 ±

1.78, and 50.1% (n=176) reported no current pain. The Musculoskeletal Burden Index (combining 12-month and 7-day scores) had a mean of 3.40 ± 3.85. The majority of trainees (65.0%) fell into the low-burden category (score 0–4), while 23.6% had moderate burden, 8.8% had high burden, and 2.6% had very high burden.

Table 3: Pain Severity Scores (12-Month, 7-Day, and Burden Index)

Score Category	n	%
12-Month Pain Score (0–9)		
0 (No pain)	151	43.0%
1–2 (Mild)	84	23.9%
3–4 (Moderate)	58	16.5%
5–6 (Moderate-Severe)	41	11.7%
7–9 (Severe)	17	4.8%
Mean ± SD	**2.13 ± 2.27**	–
Median (IQR)	1 (0–3)	–
Past 7-Day Pain Score (0–9)		
0 (No current pain)	176	50.1%
1–2 (Mild)	93	26.5%
3–4 (Moderate)	51	14.5%
5–6 (Moderate-Severe)	22	6.3%
7–9 (Severe)	9	2.6%
Mean ± SD	**1.27 ± 1.78**	–
Median (IQR)	0 (0–2)	–
Musculoskeletal Burden Index (0–18)		
0–4 (Low)	228	65.0%
5–9 (Moderate)	83	23.6%
10–14 (High)	31	8.8%
15–18 (Very High)	9	2.6%
Mean ± SD	**3.40 ± 3.85**	–
Median (IQR)	2 (0–5)	–

As shown in table (4), the functional impact of MSKIs was substantial. Overall, 42.2% (n=148) of trainees reported being limited in performing their usual work over the past 12 months, and 33.0% (n=116) were completely prevented from performing their usual duties. The mean Functional Impact Score was 1.22 ± 1.40 (range 0–3). Critically, nearly one-third of the cohort (29.6%, n=104) had a severe functional impact (Score 3).

Table 4: Functional Impact of Musculoskeletal Injuries

Parameter	n	%
Limited in performing usual work (12 months)	148	42.2%
Prevented from performing usual work	116	33.0%
Functional Impact Score (0–3)		
Score 0 (No impact)	171	48.7%
Score 1 (Mild impact)	34	9.7%
Score 2 (Moderate impact)	42	12.0%
Score 3 (Severe impact)	104	29.6%

Mean ± SD	1.22 ± 1.40	–
Injury Impact Severity		
No/Low impact (Score 0–1)	205	58.4%
Moderate impact (Score 2)	42	12.0%
High impact (Score 3)	104	29.6%

Pharmacological management was commonly used, with 29.1% (n=102) of trainees reporting the use of oral painkillers (NSAIDs), of which Panadol/Panadol Extra (2.8%) and Rofenac (2.6%) were the most frequently mentioned. Topical analgesics were used by 25.9% (n=91), with Mov Cream (3.4%) and Rofenac (2.6%) being the most common. Oral muscle relaxants and topical muscle relaxants were each used by 11.4% of the cohort. However, only 4.6% (n=16) received physiotherapy, and a mere 15.1% (n=53) complied with prescribed exercises. Shockwave therapy was rarely used (0.9%). Despite these interventions, 17.7% (n=62) still reported persistent pain as in table (5).

Table 5: Pain Management and Treatment Modalities Utilised

Treatment Modality	n	% (N=351)
Oral painkillers (NSAIDs)	102	29.1%
– Panadol / Panadol Extra	10	2.8%
– Rofenac	9	2.6%
– Brufen / Sapofen	6	1.7%
– Rilaxon	4	1.1%
– Voltaren	4	1.1%
– Others	6	1.7%
Oral muscle relaxants	40	11.4%
Topical analgesics (pain creams)	91	25.9%
Topical muscle relaxants	40	11.4%
– Mov Cream / Mov	12	3.4%
– Rofenac (topical)	9	2.6%
– Rilaxon (topical)	5	1.4%
– Voltaren (topical)	5	1.4%
Physiotherapy / natural treatment	16	4.6%
Compliant with prescribed exercises	53	15.1%
Received shockwave therapy	3	0.9%
Sought external treatment	38	10.8%
Returned to exercise/training	53	15.1%
Pain still present (persistent)	62	17.7%

In table (6), chi-square analysis revealed statistically significant associations between MSKI prevalence and several demographic and lifestyle factors. The strongest association was observed with BMI category ($\chi^2 = 17.32$, df = 3, $p < 0.001$), where obese trainees demonstrated a strikingly high prevalence of 92.3% compared to 51.5% in normal-weight trainees. Training frequency ($\chi^2 = 9.82$, df = 3, $p = 0.020$) also showed a significant association, with trainees training 5–7 times per week having the highest prevalence (63.6%), while those who did no sports had the lowest (40.0%). Education level ($\chi^2 = 12.25$, df = 3, $p = 0.006$) was significantly associated with injury prevalence, with intermediate-level trainees showing the highest rate (72.7%). Previous injury history ($\chi^2 = 3.92$, df = 1, p = 0.048) was also significantly associated, as trainees with prior injuries had a prevalence of 88.9% compared to 56.1% in those without. In contrast, smoking status ($\chi^2 = 3.99$, df = 3, p = 0.263) and presence of chronic disease ($\chi^2 = 0.54$, df = 1, p = 0.462) did not demonstrate statistically significant associations with MSKI prevalence, suggesting that these factors may play a lesser role in injury risk within this population.

Table 6: Association Between Demographic Characteristics and MSKI Prevalence

Characteristic	**Category**	**Total (n)**	**MSKI Present (n)**	**MSKI Prevalence (%)**	**χ^2**	**df**	**p-value**
BMI Category	Underweight	8	4	50.0%	17.32	3	**<0.001**
	Normal	198	102	51.5%			
	Overweight	119	70	58.8%			
	Obese	26	24	**92.3%**			
Education Level	University	238	131	55.0%	12.25	3	**0.006**
	Preparatory	78	51	65.4%			
	Final / Secondary	24	10	41.7%			
	Intermediate	11	8	72.7%			
Smoking Status	Non-smoker	234	132	56.4%	3.99	3	0.263
	Traditional cigarettes	23	12	52.2%			
	Electronic cigarettes	19	12	63.2%			
	Nicotine pouches	75	44	58.7%			
Training Frequency	1–2 times/week	163	92	56.4%	9.82	3	**0.020**
	3–4 times/week	107	60	56.1%			
	5–7 times/week	66	42	63.6%			
	No sports	15	6	40.0%			
Chronic Disease	Present	16	10	62.5%	0.54	1	0.462
	Absent	335	190	56.7%			
Previous Injury	Present	9	8	88.9%	3.92	1	**0.048**
	Absent	342	192	56.1%			

DISCUSSION

This cross sectional epidemiological study aims to present the first current baseline information about the prevalence, anatomical distribution, functional implications and treatment of musculoskeletal injuries (MSKIs) in the military trainees of Saudi Arabia. The findings indicate that a significant number of injuries are occurring among military trainees, with a prevalence of 57.0% for the 12 month period prior to the study (MSKI), and warrant prompt action by military health planners, training commanders and rehabilitation services. The findings are of special significance as there is limited epidemiological information available for military populations in the Middle East, with the particular operational environment of Middle Eastern training institutions.

This prevalence of 57.0% was significantly higher than the prevalence of medical attention injuries (22.8%) and time loss injuries (31.4%) reported in the global systematic review and meta analysis conducted by Murphy et al. [8] which included 41 studies and 451,782 recruits from all over the world. This difference may be attributed to methodological differences, as our study included all self reported pain over 12 months, regardless of whether injuries were mild or moderate, or if they required medical attention; whereas most studies in [8] used medical record or time loss definitions. This wider capture offers a more representative estimate of the actual burden of injury, and highlights the importance of having consistent surveillance definitions among military populations. Even after 20 years of research, there has been little to no improvement in the rates of injury, recognizing that this is a persistent issue and necessitates new methods of prevention, Murphy et al. [8] wrote.

This prevalence rate is also higher than that of Nye et al. [9] who reported an incidence of 12.5% in 67,525 US Air Force basic trainees using ICD codes (International Classification of Diseases) which only record injuries that are treated, thus underrepresenting the true incidence. Nye et al. [9] reported an overall incidence density rate of 18.3 injuries per 1000 person weeks, an injured trainees were 3.01 times more likely to be discharged and 2.88 times more likely to be graduated late, and it cost more than $43.7 million in medical and non medical costs. Despite the methodological differences, the much higher prevalence in our Saudi cohort suggests significant questions regarding the intensity of training, recovery periods and/or injury surveillance systems in Middle Eastern military training programmes compared to those in the West. But our rate of 57.0% is similar to the 51% of overuse injuries reported by Taanila et al. [10] for Finnish conscripts, where more complete injury surveillance in the comprehensive clinic included both acute and overuse injuries. This similarity indicates that the burden of MSKIs during military training may be significantly underestimated from administrative or time away from activity data alone, and overuse injuries are likely a highly under recognised category of the overall burden of injury.

Our cohort's anatomical distribution clearly shows a preference for the lower extremities and lumbar spine. Lower back was most commonly involved (44.7% in 12 months, 27.1% in 7 days) followed by knee (31.6% in 12 months, 19.4% in 7 days). The pattern of the most common injuries is confirmed by the results of Dijksma et al. [11] who found that for Royal Netherlands Marine Corps and Airmobile Brigade trainees, the most frequent areas of injury were the foot, knee, leg and back, and that MSKIs resulted in dropouts of 23 25%. The average number of training days for the entire cohort off due to a MSKI varied between 8.3 and 20.8 days per injury, and most of the care received was for activity restriction and referral to physiotherapy [11]. The 12 15 hours of daily training, including loaded marching, obstacle

courses, prolonged standing etc. impose a high biomechanical burden on the lumbar spine and knee joints, representing some of the key factors in the risk of developing overuse pathology outlined by Sammito et al. [13] as an extrinsic training load.
The most common injury mechanisms reported in our study were running (47.0%) and military drills (43.5%), which indicate that basic training activities are very intensive and repetitive. Interestingly, 39.5% of injured trainees reported that they did not get any rest after injury and 8.0% reported 1 3 days of rest. This behavior seems to be a culture of stoicism and under reporting, perhaps due to fear of appearing weak or worry about training delays. This is likely to contribute to injury chronicity and recurrence as has been highlighted by the extensive literature on risk factors [13] and a need for appropriate recovery, early intervention and modification of extrinsic training factors. The fact that only 17.7% of the patients with pain still reported pain after treatment suggests that the lack of adequate rest could be another factor contributing to the high rates of persistent pain reported in this study, which is similar to the findings of Dijksma et al. [11] of significant restricted training days when injury is not treated promptly and effectively.
Nearly one third (29.6%) had a severe functional impact (score 3) and 42.2% of trainees reported limitation in performing their usual work, indicating that the functional impact of MSKIs were substantial. Such incidents have significant operational consequences such as injury related functional limitations affecting training effectiveness and medical attrition. Dijksma et al. [11] also reported that 25% of their recruits that dropped-out of elite military training programs did so due to MSKIs, with overall drop-out from the Marine Corps and Airmobile Brigade of 53.9% and 52.6%, respectively. The economic burden also is significant; Nye et al. [9] found that injuries during US Air Force Basic Training cost the Air Force more than $43.7 million for medical and non medical expenses and that injured trainees are three times more likely to be discharged and almost three times more likely to graduate late. The operational and fiscal impacts highlight the need for effective prevention and rehabilitation measures, especially since those lost investment in training and human capital are significant costs of MSKI related dropout.
Pharmacological interventions were the main method used for pain management in our cohort with 29.1% using an oral NSAID and 25.9% using topical analgesics; very few people in this cohort used physiotherapy (4.6%) and only 15.1% followed the exercise guidelines. This is a concerning gap in the provision of rehabilitation, as active intervention like physiotherapy, therapeutic exercise and active treatment are integral parts of evidence based management of MSKI. Low uptake of physiotherapy may be linked to a limited access, insufficient referral pathways and/or cultural preferences for medication over active physiotherapy. Dijksma et al. [11] reported that military physicians providing MSKI care primarily provided the information specific to the injury and self management options, set specific activity restrictions, and referred to physiotherapy, but still had high dropouts. When reviewing the findings of the current study, 17.7% of our trainees still reported persisting pain, further evidence that current rehabilitation frameworks are not effective for a significant proportion of injured individuals, highlighting the need for rehabilitation to be improved as suggested by the injury prevention models put forward by Sammito et al. [13] and Foulis et al. [15].
Analysis of risk factors showed significant associations between the prevalence of MSKI and BMI category ($p<0.001$), training frequency ($p=0.020$), education level ($p=0.006$) and previous injury history ($p=0.048$). Similarly, the strikingly high prevalence among obese trainees (92.3% vs 51.5% in normal weight) is consistent with other studies showing that US Army trainees

who were over body fat standards were 47% more likely to sustain an MSKI and had 49% more healthcare utilisation than weight qualified trainees [12]. Cowan et al. [12] also found that age >19 years and smoking history were important factors, but smoking was not in either our cohort or any other study included in this review. Taanila et al. [10] also found that there was a U shaped association between overuse injuries and body composition, as both being underweight and being overweight were associated with increased HR for overuse injuries, and a leisure time physical activity prior to military entry was protective. The increased association of increased training frequency (63.6% for those training 5 7 days/week) further supports the dose response relationship between training volume and injury risk. Interestingly, Murphy et al. [8] noted that injury incidence rate was lower for longer recruit training programmes, indicating that adequate periodisation, incremental loading and minimising daily overload are important modifiable factors. The relationship of education level may be attributed to differences in health literacy, and the high association with previous injury history is consistent with the concept that previous injury is a strong predictor of subsequent injury, which has been well documented, presumably due to an incomplete recovery of injuries or to biomechanical deficits remaining from previous injuries [13].

Unlike in Cowan et al. [12] who found smoking as a significant risk factor, the current study did not reveal a statistical significance between the status of smoking and the prevalence of MSKI ($p = 0.263$). The difference might be because only 6.6% of our cohort used traditional cigarettes, and 21.4% used nicotine pouches. Nicotine pouch use may have different physiological effects on tissue healing and inflammation. A lack of significance might also be due to the limited power of the analyses performed at the sub-group level, especially for some of the sub-groups in this study that were relatively small.

The multifactorial nature of MSKI risk is well summarized in the qualitative systematic review conducted by Sammito et al [13] who found 57 potential risk factors in 176 original papers and 3 meta analyses, 21 of which had moderate to strong evidence. They have created an injury prioritising model that categorises injury factors by modifiable and non modifiable, and extrinsic and intrinsic factors, and added the concept of "order of importance" to guide intervention strategies [13]. This model offers valuable guidelines for planning specific interventions in Saudi military contexts by enabling planners to prioritize those factors that are most influential and changeable first. The prospective study protocol of Hughes et al. [14] also highlights the need for combining multiple data sources, such as anthropometrics, tibial microarchitecture, whole body bone mineral density, muscle cross sectional area, body composition, muscle function, blood markers (musculoskeletal, genetic, nutritional), physical activity questionnaires, sleep questionnaires, personality questionnaires and medical history in order to create strong multivariate prediction models. They are following up on their injuries for 2 years after graduation, which will give them extremely useful longitudinal data on injury recurrence and long term outcomes [14].

Recently, Foulis et al. [15] created a multi-stage risk model for the US Army Basic Combat trainees which incorporated demographic, anthropometric and body composition, nutritional status, medical and health history, history of sports and physical activity, psychological factors (pain, grit, hardiness), and sleep parameters. They obtained areas under the receiver operating characteristic curve of 0.701 for the entire cohort, 0.661 for males and 0.678 for females [15]. The system of tiered interventions based on a traffic light system (green, amber, red) to stratify risk is a practice-based, evidence-based approach that can be adapted for use within military training institutions in Saudi Arabia to identify individuals at risk of negative outcomes early on in the training process and guide their implementation of targeted interventions with multiple factors. Our results are similar to that of the international literature with high prevalence rates, lower extremity and lumbar predominance, functional disability and the significance of BMI, training load and previous injury, which supports the global nature of the MSKI problem during military training. This is a persistent problem, as Murphy et al. [8] pointed out, with little change in injury rates over the last 20 years, suggesting the need for a paradigm shift towards data-driven, proactive injury prevention rather than reactive treatment. The models put forward by Sammito et al. [13], Hughes et al. [14] and Foulis et al. [15] offer concrete routes to such a shift, focusing on the need for a comprehensive risk assessment, ongoing surveillance and multiple intervention strategies to address the whole range of modifiable risk factors.

Limitations

The authors state that there are some limitations to the study. The cross-sectional design does not allow causal inferences to be made and requires longitudinal studies to substantiate relationships among risk factors. The use of self-reported information can impose biases and a lack of direct verification can impact on the accuracy of the diagnosis. The all-male sample limits generalizability to females and the study was conducted in one Saudi institutional setting that may be different from other Saudi training institutions. A smaller sample size reduces the statistical power for the subgroup analyses. Furthermore, the factors that were assessed were not completely exhaustive, as not all potentially risky factors found in the literature were evaluated.

CONCLUSION

The study is the first large-scale epidemiological study of MSKIs in Saudi military trainees, and found a prevalence rate of 57.0% over a 12-month period, with the lowest rates of injury occurring in the lower back and knees. 25% of trainees had a significant functional impairment. Pharmacological treatment is heavily relied on, little physiotherapy is used and there is a high prevalence of persistent pain which demonstrates significant rehabilitation gaps. There are opportunities to prevent injury including identified risk factors such as obesity, high training frequency, lower education, and previous injuries. Results suggest that there is a need for better injury surveillance, evidence based training periodisation, more access to physiotherapy and models of multifactorial risk assessment. Longitudinal studies, objective injury verification, a larger number of female trainees, and a wider variety of risk factors should be studied in the future to aid in the management of injury and improve trainee health in a military setting.

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