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Musculoskeletal injuries among overweight army trainees: incidence and health care utilization

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Background Musculoskeletal injuries are a major cause of morbidity in military training. They are more common among overweight/obese individuals, and the prevalence of overweight/obesity in the military has increased. During strong economic periods, the military can be challenged to recruit enough qualified personnel, and physical standards are sometimes relaxed.

Aims This study was conducted to compare the incidence of and outpatient utilization for training-related overuse injuries among men who were over body fat (OBF) standards compared with those who were weight qualified (WQ).

Methods All study subjects were men ≥18 years old, who were classified as OBF or WQ and were followed for 90 days. During this period, everyone entering through the study sites was required to take a physical fitness test (5 min step test). Only individuals passing the fitness test were included in these analyses.

Results There were 812 OBF and 6511 WQ study participants. OBF were 47% more likely to experience a musculoskeletal injury and had 49% higher health care utilization. Other significant factors included age >19 and a history of smoking.

Conclusions Among this population who had passed a fitness test, those who were OBF had a substantially higher risk of injury and higher utilization for these injuries. Because the recruiting environment is much better, military entrance standards have been tightened, but should the economy improve substantially the military may again be challenged to recruit adequate numbers of personnel, and the lessons learned in this project may prove valuable.

Key words armed forces; BMI; epidemiological studies; fitness tests; injury; male; musculoskeletal; obesity.

Introduction

Musculoskeletal injuries are a major cause of morbidity and lost duty time in most military basic training programmes. The burden on the United States military (military) health care system can be substantial: there were almost 750 000 injury-related musculoskeletal conditions in 2006 among non-deployed active duty service members [1]. Lower extremity overuse injuries, the most common injuries in basic training, [2] accounted for almost 4 million days of limited duty for active duty service members in 2004 [3]. Despite knowledge about risk factors for the prevention of musculoskeletal injuries, overuse injuries have not decreased in the US Department of Defense [4]. The prevalence of military service members who are overweight and obese has more than doubled since 2003 [5]. The increase in the number and percentage of overweight and obese applicants entering the US military may lead to an increase in incidence of musculoskeletal injuries and health care costs in basic training.

Studies of the impact of obesity on injuries have mostly been done in civilian settings. Finkelstein *et al.* [6] showed that the odds of sustaining selected injuries, such as strains and sprains, and overall injuries (including falls, motor vehicle- and sports-related injuries) increased with increasing body mass index (BMI). High school football players with higher BMI and with higher body fat had increased rates of lower extremity injuries [7]. Obesity, as measured by BMI, has been associated with overuse syndromes, osteoarthritis and various other musculoskeletal disorders [8].

The Assessment of Recruit Motivation and Strength (ARMS) study [9] allowed otherwise-eligible applicants exceeding US Army (Army) weight-for-height and body fat standards [over body fat (OBF)] to obtain an entrance waiver (ARMS waiver) if they were able to pass a pre-accession physical fitness test (ARMS test). Although this study provided OBF individuals an opportunity to serve in the military, the potential risks of morbidity to these recruits were not known. The purpose of this study was to compare the incidence and outpatient utilization of training-related overuse injuries (in the first 90 days of military service) among men who received ARMS waivers for exceeding body fat standards compared with those who were weight qualified (WQ) and who also passed the ARMS test.

Methods

All study subjects were male active duty members of the Army who entered for the first time between February 2005 and September 2006 at six Military Entrance Processing Stations: Atlanta, GA; Buffalo, NY; Chicago, IL; Sacramento, CA; San Antonio, TX, and San Diego, CA. Subjects were followed for 90 days after entry, as this approximates the 10 weeks period of basic combat training, plus 1–2 weeks spent in administrative in-processing prior to training initiation. This study was approved by the Institutional Review Board. To be included in the study, subjects had to be ≥18 years of age and provide written informed consent.

During the study period everyone entering the Army through one of the study sites was required to take a pre-accession physical fitness test (ARMS test), consisting of a 5 min step test at a pace of 120 steps per minute at a step height of 16 inches and a minimum of 15 push-ups to be completed in one minute. Additional information on the fitness test is available elsewhere [10]. For these analyses, only the step-test results were considered. Applicants exceeding weight-for-height and body fat per cent, up to 30% for men (limit set to the maximum body fat allowable to those ≥40 years), were required to pass the test before being allowed to enlist. If they passed, they were given a waiver for accession. WQ applicants were also required to take the test, but they were not obligated to pass in order to access; their performance on the test had no impact on their enlistment eligibility.

Enlistment and discharge data were provided by the Center for Accession Research, US Army Accession Command. Outpatient medical encounter data were supplied by the US Army Medical Command Patient Administration Systems and Biostatistics Activity. All diagnoses from each outpatient encounter were captured.

For this study, only those men passing the ARMS test were considered; all others were excluded from these analyses. The primary predictor of interest was ARMS waiver status (OBF versus WQ). WQ participants includes those who where qualified, recommended or denied a waiver due to initially being OBF standard and subsequently lost weight or body fat to meet the standard. OBF participants include those granted a waiver. Other covariates of interest recorded at the time of testing included age (18–19, 20–24 and ≥25 years), race (black, white or other) and smoking history (ever/never).

The end points utilized have been studied in other military populations and are generally considered overuse injuries that frequently occur among military trainees, runners and other physically active populations [11–14]. Overuse injuries have been defined as 'long-term energy exchanges resulting in cumulative microtrauma' [13]. We identified overuse injuries based on International Classification of Diseases, 9th Revision (ICD-9) codes (715–733), plus sprains and strains (Codes 843–847). A complete list of ICD–9 codes used in the analysis can be found in Appendix 1 (available as Supplementary data at *Occupational Medicine* Online). Injury sites included ankle/foot, knee, lower leg, hip/thigh/pelvis and lumbar and sacrum/coccyx regions of the back (back). Specific conditions included sprain/strain, stress fracture/stress reaction of bone/pathologic fracture (bone stress injuries), tendonosis/tendonitis (tendonitis), arthropathy, pain, fasciitis, enthesopathy and bursitis. However, due to the small number of diagnoses, fasciitis, enthesopathy and bursitis injury codes were captured as cases under the overall category for overuse injuries only and were not evaluated separately.

With the exception of codes for selected bone stress injuries, codes with no specific anatomic location (e.g. not otherwise specified) were excluded. For individuals with bone stress injury Codes 733.10, 733.19 or 733.95, where a location of the condition was not specified, a determination of lower extremity injury was made on the basis of reviewing diagnosis codes from all outpatient visits in the first 90 days of service. Two authors (D.N.C. and S.A.B.) independently reviewed the diagnoses. Differences were resolved through consultation between authors.

For evaluating the overall incidence, we used the first outpatient medical encounter with any of these overuse injury diagnoses (an individual was counted only once, regardless of the number of injuries). For analyses of utilization, all individual medical encounters were captured, defined as all visits on separate days with any overuse injury diagnosis or visits for physical therapy following one of the eligible overuse injury diagnoses. Inpatient records were not utilized in this study.

Categorical analyses for the study population were assessed with chi-square tests. Incidence rate (IR) was defined as the number of initial events per 1000 person-days of military service, and the rate ratio (RR) with 95% confidence interval (CI) was used to compare the risks between groups. Cox proportional hazards regression

Table 1. Demographic distribution of ARMS study participants by ARMS waiver status

Total	OBF (N = 812), n (%)	WQ (N = 6511), n (%)	P
Age (years) on accession date or shipping date			
18–19	352 (43)	2982 (46)	NS
20–24	371 (46)	2727 (42)	
>25	89 (11)	802 (12)	
Race			
White	602 (74)	4769 (73)	<0.001
Black	60 (7)	749 (12)	
Other	150 (18)	993 (15)	
Tobacco use			
No	621 (76)	4706 (72)	<0.05
Yes	186 (23)	1723 (26)	
Missing	5 (1)	82 (1)	
BMI			
Underweight (× < 18.5)	0 (0)	236 (4)	<0.001
Normal weight (<18.5 × <25)	6 (1)	3667 (56)	
Overweight (<25 × <30)	102 (13)	1840 (28)	
Obese (>30)	704 (87)	768 (12)	
Attrition			
90 Days	43 (5)	188 (3)	<0.001

Table 2. Incidence rates and crude hazard ratios for overuse injury by ARMS waiver status

	OBF			WQ			HR[b] (95% CIs)
	n	1000 pd[a]	IR	n	1000 pd[a]	IR	
First musculoskeletal injury	294	57	5.2	1761	494	3.6	1.46 (1.29–1.65)***
First musculoskeletal injury by type							
Pain	205	63	3.32	1214	522	2.32	1.43 (1.23–1.65)***
Sprain/strain	124	66	1.89	726	546	1.33	1.42 (1.18–1.72)***
Arthropathy	24	70	0.34	148	572	0.26	1.32 (0.86–2.03)
Tendonitis	17	71	0.24	120	573	0.21	1.15 (0.69–1.91)
Bone stress injury	16	71	0.23	104	576	0.18	1.25 (0.74–2.12)
First musculoskeletal injury by location							
Ankle/foot	134	65	2.07	684	545	1.25	1.64 (1.37–1.98)***
Lower leg	113	67	1.70	710	547	1.30	1.31 (1.07–1.60)**
Back	86	68	1.27	372	561	0.66	1.92 (1.52–2.42)***
Knee	64	69	0.93	408	562	0.73	1.29 (0.99–1.68)
Thigh/pelvis/hip	32	70	0.46	195	571	0.34	1.34 (0.92–1.94)
Unspecified lower extremity, bone stress injury	4	71	0.06	31	578	0.05	1.05 (0.37–2.97)

[a]1000 pd = 1000 person-days.

[b]Hazard ratio for injury for OBF versus WQ.

**$P < 0.01$, ***$P < 0.001$.

models were used to calculate the adjusted proportional hazards ratio of musculoskeletal overuse injury among OBF relative to qualified subjects, controlling for age and smoking. Utilization rate was defined as the number of medical encounters per 1000 person-days follow-up. Poisson regression models were used to assess the relationship between utilization during the first 90 days in the Army and OBF status, adjusted for the other independent variables. All analyses were performed using SAS 9.2 (SAS Institute, Cary, NC).

Attributable risk per cent [15] (AR%) was calculated using the formula [substituting hazard ratio (HR) for risk or odds ratio] (1 − HR)/HR) × 100 to estimate the proportion of overuse injuries that are due to exceeding body fat standard and to estimate the incidence if all the subjects were WQ.

Table 3. First musculoskeletal injury within first 90 days of service: hazard ratios for OBF versus WQ

		HR[a]	95% CI
ARMS waiver status	OBF versus WQ	1.47***	1.30–1.66
Age group	18–19	1.00	
	20–24	1.30***	1.19–1.43
	>25	1.55***	1.36–1.76
Tobacco use	None	1.00	
	Yes	1.29***	1.18–1.42

[a]Adjusted variables: ARMS waiver status, age group, tobacco use.

***$P < 0.001$.

Results

There were 812 OBF and 6511 WQ study participants (Table 1). Study participants' race differed significantly between the OBF and WQ groups, notably with fewer black individuals in the OBF group. A larger percentage of WQ individuals had a history of smoking compared with OBF. Ninety days attrition was higher in the OBF group compared with WQ.

Among OBF study subjects, the crude injury IR was 5.2/1000 person-days compared with 3.6/1000 person-days among WQ subjects ($P < 0.001$) (Table 2). Pain and sprain/strain were the most common overuse conditions among both OBF and WQ by a substantial margin. Injuries to the ankle/foot and lower leg were most common among both OBF and WQ. OBF were at significantly increased risk of pain, sprain/strain and other overuse injuries, but not for other types of injury. OBF were also at increased risk of injury to the ankle/foot, back and lower leg, but not for injuries to other locations.

OBF study subjects were 47% more likely to experience any overuse injury compared with WQ, after controlling for age and smoking (HR = 1.47, 95% CI 1.30–1.66]. Compared with study subjects in the youngest age group (18–19 years), subjects in 20–24 and ≥25 age groups were 30 and 55% more likely to have an overuse injury, respectively. History of smoking was associated with a 29% greater risk of injury (Table 3). Race was not associated with injury (data not shown).

The incident AR% associated with OBF was 32%. Crude health care utilization rates for OBF compared with WQ were 10.6/1000 person-days and 7.1/1000 person-days, respectively (data not shown). The crude RR for utilization for injuries was 1.49 (95% CI 1.37–1.61) greater among OBF compared with WQ (data not shown). After adjustment for age and smoking, the number of injury visits observed among OBF was 49% higher (Table 4). RRs were essentially the same when all injury-related visits, including physical therapy encounters, were included (data not shown). Utilization was 29% higher among those aged 20–24 years, and 63% higher among those ≥25 years, compared with those ≤19 years. Smokers' utilization was 22% higher than that of non-smokers. Race was not associated with utilization (data not shown).

Table 4. Adjusted[a] utilization rate ratios for musculoskeletal injuries by ARMS waiver status in the first 90 days of service

	RR	95% CI
ARMS waiver status		
WQ	1.00	
OBF	1.49***	1.38–1.61
Age group		
18—19	1.00	
20—24	1.29***	1.21–1.37
≥25	1.63***	1.50–1.77
Tobacco use		
No	1.00	
Yes	1.22***	1.15–1.30

[a]Adjusted variables: ARMS waiver status, age group, tobacco use.

***$P < 0.001$.

Discussion

This study found that men who exceeded body-fat standards were at higher risk of overuse injury and had higher health care utilization for these injuries. This study is also unique in that it quantified and evaluated risk factors for health care utilization related to weight and body fat.

We found that men exceeding the Army standards for body fat per cent were at significantly increased overall risk of an overuse injury. Risk was also significantly elevated for three of five of each category of type and location of injury examined in this study and also had significantly higher utilization for overuse injuries. In addition, we found that smokers and those over age 20 were also at greater risk of injury and had higher utilization for injuries.

OBF recruits had significantly more injuries of the foot/ankle, lower leg, and back, but not to the knee or arthropathy. This potential specificity of risk factors for different types and sites of injury deserves further study including longer periods of follow-up.

At the time that the ARMS study and programme were designed and implemented, the US Army was having difficulty meeting its recruiting needs. The concept behind ARMS was to identify persons who did not meet current accession standards but who could successfully perform in the Army, and it did that by allowing several thousand additional persons to enter, who would not have been eligible in the absence of the ARMS study and programme. Although we have documented that these individuals were at higher risk of injury, most did indeed successfully serve in the Army. Since then the recruiting environment has changed dramatically, and the Army has nearly met its entire 2011 recruiting goals early in the year. Should the economic situation in the US return to its previously

robust conditions, however, the lessons learned from the ARMS study and programme could prove quite valuable.

There were several limitations to this study. We were not able to relate overuse injury to BMI or body fat at the time of the event, as individuals may have lost or gained weight and muscle mass after accession. Neither were we able to measure the exposures (e.g., running, marching) during training, nor the specific activities being undertaken proximal to the onset of symptoms leading to an injury diagnosis. Although we tracked injuries for 90 days for these analyses, 76% of all injuries occurring in the first 6 months of military service were diagnosed within our study period (data not shown). This study was not designed to capture chronic injuries that develop over years, such as chronic knee pain or degenerative joint disease among obese individuals, so our findings may not be generalizable to populations beyond the young men we studied.

Although we found an increase in risk of injury and utilization among those exceeding the body fat standard, the case for initiating and operating a physical fitness screening programme for overweight military applicants cannot be determined with musculoskeletal injury data alone. Given the epidemic of obesity in the US, it may become necessary for the military to again consider selectively waiving body fat standards. However, before any such change is operationalized, appropriate economic decision analyses should be conducted to determine the balance between the risks and associated costs and the benefits of a larger pool of potential military applicants.

This study has important implications beyond the military. Other occupations, such as police and fire-fighters, are also facing the challenges of obesity in a similar context of high physical demands [16,17]. These occupations recruit from the same pool of young adult civilian applicants who are increasingly overweight and less fit [18–20]. Because obesity and sedentary lifestyle are a relatively new phenomenon in adolescents and young adults, the extent of their impact on overuse injuries is likely just being realized.

Key points

- There are limited data on the impact of obesity on risk of overuse musculoskeletal injuries and types of health care utilization. Much of the existing literature does not control for fitness differences between obese and non-obese individuals.
- Exceeding body fat standards was associated with a 47% greater risk of injury and 49% higher utilization of health care. Age and smoking were also significant risk factors.
- Not all sites and types of injury were significantly greater among the obese.

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