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original research

Description and Rate of Musculoskeletal Injuries in Air Force Basic Military Trainees, 2012–2014

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Context: Musculoskeletal injuries are common in military trainees and have significant medical and operational effects.

Objective: To provide current musculoskeletal injury epidemiology data for US Air Force basic military trainees.

Design: Descriptive epidemiologic study with cross-sectional features.

Setting: US Air Force Basic Military Training, Joint Base San Antonio-Lackland, Texas.

Patients or Other Participants: All recruits who entered training between July 1, 2012, and June 30, 2014.

Main Outcome Measure(s): Incidence density rate of all musculoskeletal injuries (stratified by body region and type) and factors and costs associated with injuries.

Results: Of the 67 525 trainees, 12.5% sustained 1 or more musculoskeletal injuries. The overall incidence density rate was 18.3 injuries per 1000 person-weeks (15.1 for men and 29.4 for women). The most common diagnosis (n = 2984) was *Pain in joint, lower leg*, as described in the *International Classification of Diseases, Ninth Revision*, *Clinical Modification*, code 719.46. Injuries were more common among those with lower levels of baseline aerobic and muscular fitness. Injured trainees were 3.01 times (95% confidence interval = 2.85, 3.18) as likely to be discharged, and injured trainees who did graduate were 2.88 times (95% confidence interval = 2.72, 3.04) as likely to graduate late. During the surveillance period, injuries resulted in more than $43.7 million in medical ($8.7 million) and nonmedical ($35 million) costs.

Conclusions: Musculoskeletal injuries, predominantly of the lower extremities, have significant fiscal and operational effects on Air Force Basic Military Training. Further research into prevention and early rehabilitation of these injuries in military trainees is warranted.

Key Words: warrior athletes, physical fitness, injury epidemiology

Key Points

- Between July 1, 2012, and June 30, 2014, the Air Force trained 67 525 recruits in Basic Military Training. Of these, 12.5% sustained 1 or more musculoskeletal injuries.
- Injured trainees were 3.01 times as likely to be discharged, and injured trainees who did graduate were 2.88 times as likely to graduate late.
- During the surveillance period, injuries resulted in more than $43.7 million per year in medical ($8.7 million) and nonmedical ($35 million) costs.
- Efforts to prevent injuries and rehabilitate injured trainees rapidly are likely to result in significant cost savings.

Each year, more than 30 000 civilian recruits enter US Air Force Basic Military Training (BMT) at Joint Base San Antonio (JBSA)-Lackland, Texas. Drawn from a population of increasingly sedentary, obese, and less physically fit adolescents,[1–4] these recruits are challenged to master each aspect of the 8.5-week basic training curriculum, of which physical fitness is a major component. Trainees participate in 5 to 6 physical training sessions per week (45 to 60 minutes per session), which generally alternate between aerobic development/running days and strength-training days. Aerobic workouts include 30 minutes of continuous running, divided into timed and self-paced segments. Strength training consists of body-weight exercises focusing on the upper extremities and core. Trainees are tested 4 times using the US Air Force Fitness Assessment, a standardized test comprising an abdominal circumference measurement, 1 minute of push-ups, 1 minute of sit-ups, and a timed 1.5-mi (2.4-km) run.[5] To graduate, trainees must meet US Air Force age- and sex-specific fitness standards. In addition to physical training, trainees perform extensive marching, drill, and ceremony training and a week of simulated deployed training (including an obstacle course; chemical, biological, and nuclear weapons training; M-16 rifle training; and pugil-stick training).

Musculoskeletal injuries are common at all US military training sites.[6,7] In settings such as Army Basic Combat Training, it has been estimated that approximately 25% of male and 50% of female trainees experience injuries.[8–10] Authors[9] of a recent systematic review of Army Basic Training injury risk factor studies found that among male recruits, increasing age, smoking history, and prior sedentary lifestyle were associated with increased injury risk. In addition to the pain and suffering experienced by the individual trainee, musculoskeletal injuries incur substantial financial costs, interrupt training, and prompt medical discharges. The end result is fewer trained, healthy personnel available to complete the mission of the Armed Forces.[6,7,11–13]

To our knowledge, only 2 groups[13,14] have published studies describing the epidemiology of trainees' musculoskeletal injuries in Air Force BMT. Because these studies are nearly 2 decades old and many changes have been made in BMT during the intervening time (eg, the length of training and the physical fitness program), a new analysis was required. We conducted an observational study to determine current rates, patterns, and costs of musculoskeletal injuries in the Air Force BMT setting. The findings may expose research needs and guide primary, secondary, and tertiary injury-prevention programs.

METHODS

We obtained demographic (age and sex), training outcome, anthropometric (body mass index [calculated as weight in kilograms divided by height in meters squared] and abdominal circumference), physical fitness, and musculoskeletal-injury data on all Air Force basic military trainees who entered training between July 1, 2012, and June 30, 2014. Training outcome data included graduation or discharge (as a binary variable), on-time graduation (as a binary variable among those who graduated), total days in training (as a continuous variable), and total days out of training for a musculoskeletal injury (as a continuous variable).

Anthropometric and physical fitness data reflect measurements and scores on the initial fitness assessment, which is typically completed within 1 week of arrival. However, this dataset was incomplete; those with missing data were excluded from analysis only for the component(s) of the fitness assessment that were not completed. Except for the musculoskeletal-injury data, which were derived from the Armed Forces Health Longitudinal Technology Application (the electronic health record of the Department of Defense [DoD]), all data were retrieved from the Basic Training Management System, a personnel records system maintained by the 737th Training Group at JBSA-Lackland. An incident case of an injury was defined by having an *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) code corresponding to a musculoskeletal injury (Table 1) in the outpatient medical record in any diagnostic position (ie, the primary diagnosis or any subsequent diagnosis). Injuries were stratified by body region and type, using a modified version of a previously published matrix,[15] such that each cell of the matrix corresponded to a unique combination of body region and injury type (Table 1). To minimize duplicate counting (eg, labeling the diagnosis in a follow-up visit as a second incident injury), trainees could receive only 1 incident diagnosis per cell of the matrix; they could receive multiple incident diagnoses only in different cells. To improve data quality, we reviewed charts for many nonspecific *ICD-9-CM* codes, including 716.9 (n = 6), 717.89 (n = 4), 717.9 (n = 11), 719.8 (n = 2), 719.9 (n = 9), 722.93 (n = 1), and 724.5 (n = 198), and then manually assigned these injuries to the most appropriate cell of the matrix.

We stratified the population into 2 cohorts: those who sustained 1 or more injuries and those who sustained no injuries. We used summary statistics to describe these cohorts and compared them using χ^2 tests (for categorical variables) and unpaired *t* tests (for continuous variables); we further stratified the cohorts by sex for anthropometric and physical fitness variables. Prevalence ratios with 95% confidence intervals (CIs) were obtained for demographic and training outcome variables. We calculated overall and sex-specific incidence density rates by dividing the count of incident injuries by total person-time for the population or total person-time for each sex. *Person-time* for each trainee was defined as the total days in training, calculated as the duration between the entrance and departure dates. Analyses were performed using OpenEpi software (version 3.03; Atlanta, GA); 2-sided P values $<.05$ were considered statistically significant. For comparisons of injured and uninjured cohorts, a post hoc Bonferroni correction was applied to adjust the P value for multiple comparisons.

Total burden of care was defined as the sum of medical and physical therapy appointments accrued by the population. Local costs for medical ($184/encounter) and physical therapy ($104/encounter) appointments (C.C. Karahan, group practice manager, written communication, February 2015) were used to determine the direct medical costs associated with the injuries. Radiographic and laboratory costs were factored into these estimates. The total indirect cost was calculated as the sum of 2 training-related costs. First, for those who were discharged due to a musculoskeletal injury, the cost was calculated as $22 898 to recruit and medically clear 1 trainee (as published by the US Army[16] for fiscal year 2010) plus the total days in training multiplied by $366.03, the daily cost of Air Force basic training (V.D. Whelchel, chief of resource management, written communication, February 2015). Second, for those who were removed from training for a musculoskeletal injury but eventually graduated, the cost was calculated as the total days out of training multiplied by $366.03. This study was approved by the institutional review board of the 59th Medical Wing at JBSA-Lackland.

RESULTS

During the 2-year surveillance period, 67 525 individuals entered US Air Force BMT and accrued 639 000 person-weeks of exposure. Of these individuals, 12.5% (n = 8448) sustained 1 or more injuries. A total of 11 673 unique injuries occurred, for an overall incidence density rate of 18.3 injuries (95% CI = 17.9, 18.6) per 1000 person-weeks. Rates for men and women were 15.1 (95% CI = 14.7, 15.4) and 29.4 (95% CI = 28.6, 30.3) injuries, respectively, per 1000 person-weeks. Compared with their uninjured peers, injured trainees were more likely to be older, to spend more days in training, and to have performed worse on each component of their initial fitness assessment ($P < .001$ for all values). After stratifying by sex, we found no differences in baseline body mass index or abdominal circumference between injured and uninjured trainees. Injury risk was 87% higher among women than among men (prevalence ratio = 1.87 [95% CI = 1.79, 1.94]). Injured trainees were 3.01 times (95% CI = 2.85, 3.18) as likely to be discharged, and injured trainees who did

Table 1. Musculoskeletal Injury Matrix by Body Region and Type per *International Classification of Diseases, Ninth Revision, Clinical Modification* Codes Continued on Next Page

	Injury							
Body Region	Fracture	Stress Fracture	Dislocation	Sprains, Strains, and Ruptures	Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurologic Involvement	Osteoarthrosis
Vertebral column								
Cervical	805.0–.1	NA	839.0–839.1	847	723.1	722	722.71, 723.4	722.4
Thoracic	805.2–.3	NA	839.21, 839.31	847.1	724.1	722.11	722.72, 724.4	722.51
Lumbar	805.4–.5	NA	829.20,.30	847.2	724.2	722.1	722.73, 724.3	722.52
Sacrum/coccyx	805.6–.7	NA	839.41–839.42, 839.51–839.52	847.3–847.4	720.2	NA	NA	NA
Spine and back unspecified	805.8–805.9	733.13	839.40, 839.49, 839.50, 839.59	NA	721.7, 724.5	722.2	722.70, 724.9	722.6, 722.9
Torso								
Chest	807.0–807.4	NA	839.61, 839.71	848.3–848.4	NA	NA	NA	NA
Abdomen	NA	NA	NA	NA	NA	NA	NA	NA
Pelvis and urogenital	808.[a]	NA	839.69, 839.79	846.,[a] 848.5	NA	NA	NA	NA
Trunk	809.[a]	NA	NA	NA	NA	NA	NA	NA
Back and buttock	NA	NA	NA	847.9	NA	NA	NA	NA
Upper extremity								
Shoulder	810.[a]–811.[a]	733.11	831.,[a] 718.31	840.[a], 727.61–727.62	716.11, 719.01, 719.11, 719.41, 726.0–726.2	718.01, 718.11, 718.81, 718.91	NA	715.11, 715.21, 715.31, 715.91
Upper arm and elbow	812.[a]	733.12	832.,[a] 718.32	841.[a]	716.12, 719.02, 719.12, 719.42, 726.3	718.02, 718.12, 718.82, 718.92	NA	715.12, 715.22, 715.32, 715.92
Forearm and wrist	813.[a]	NA	833.,[a] 718.33	842.0[a]	716.13, 719.03, 719.13, 719,43, 726.4	718.03, 718.13, 718.83, 718.93	NA	715.13, 715.23, 715.33, 715.93
Hand	814.[a]–817.[a]	NA	834[a], 718.34	727.63–727.64, 842.1[a]	716.14, 719.04, 719.14, 719.44	718.04, 718.14, 718.84, 718.94)	NA	715.04, 715.14, 715.24, 715.34, 715.94
Other and unspecified	818.[a]	NA	NA	NA	NA	NA	NA	NA
Lower extremity								
Hip	820.[a]	NA	835.,[a] 718.35	843.[a]	716.15, 719.05, 719.15, 719.45, 726.5	718.05, 718.15, 718.85, 718.95	NA	715.15, 715.25, 715.35, 715.95
Upper leg and thigh	821.[a]	733.14–733.15, 733.96–733.98	NA	727.65	NA	NA	NA	NA
Knee	822.[a]	NA	836.,[a] 718.36	844.0–844.3, 717.8[a], 727.66	716.16, 717.7, 719.06, 719.16, 719.46, 726.6, 726.60–726.65, 726.69	717.0–717.6, 717.9, 718.06, 718.16, 718.86, 718.96	NA	715.16, 715.26, 715.36, 715.96
Lower leg and ankle	823.[a]–824.[a]	733.16, 733.93	837.,[a] 718.37	845.0[a], 727.67, 727.68	716.17, 719.07, 719.17, 719.47, 726.7, 726.70–726.73, 726.79	718.07, 718.17, 718.87, 718.97	NA	NA

Table 1. Continued From Previous Page

	Injury							
Body Region	Fracture	Stress Fracture	Dislocation	Sprains, Strains, and Ruptures	Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurologic Involvement	Osteoarthrosis
Foot and toes	825.[a]–826.[a]	733.94	838.[a]	845.1[a]	728.71, 734	NA	NA	715.17, 715.27, 715.37, 715.97
Other and unspecified	827.[a]	NA	NA	844.8–844.9	NA	NA	NA	NA
Unspecified								
Other/multiple	819.,[a] 828.[a]	733.19	718.38–718.39	727.69	716.18–716.19, 719.08, 719.09, 719.18, 719.19, 719.48, 719.49, 726.8, 727.2	718.08, 718.09, 718.18, 718.19, .88, 718.89, 718.98, 718.99	NA	715.09, 715.18, 715.28, 715.38, 715.98
Unspecified site	829.[a]	733.10, 733.95	839.8–839.9, 718.30	848.8–848.9, 727.60, 728.83	716.10, 719.00, 719.10, 719.40, 726.9, 727.3, 729.1	718.00, 718.10, 718.80, 718.90	729.2	715.00, 715.10, 715.20, 715.30, 715.90

Abbreviation: NA, no corresponding *International Classification of Diseases, Ninth Revision, Clinical Modification* code.
[a] All subdiagnoses were included.

graduate were 2.88 times (95% CI = 2.72, 3.04) as likely to graduate late (Table 2).

Locations and Types of Injuries

The majority of all musculoskeletal injuries (78.4%; n = 9147) involved the lower extremity (Table 3). Each of the other body regions (ie, vertebral column, torso, upper extremity, and unspecified) comprised less than 8% of musculoskeletal injuries. Injuries within the *ICD-9-CM* category of inflammation and pain accounted for 59.7% (n = 6972) of injuries, followed by sprains, strains, and ruptures (30.5%; n = 3560) and stress fractures (6.6%; n = 776). The 5 most common individual diagnoses are presented in Table 4.

Costs

Injuries resulted in 40 080 medical and 12 363 physical therapy encounters during the surveillance period, for a direct medical cost of $8 660 472. Of the 1513 trainees in this population who failed to graduate, 714 (47.2%) were discharged due to a musculoskeletal condition. These discharged individuals remained in training or medical hold for a mean duration of 66.0 days, resulting in an indirect cost of $33 603 826. An additional 123 trainees spent a total of 4139 days out of training due to a musculoskeletal injury before eventually graduating, for an additional cost of $1 514 998. The total costs associated with these injuries, therefore, exceeded $43.7 million over the 2-year surveillance period. This figure does not account for ongoing medical and disability costs for those who did not recover from their injuries before discharge.

DISCUSSION

The incidence of musculoskeletal injuries in US Air Force BMT over 2 years was 18.3 per 1000 person-weeks (15.1 and 29.4 for men and women, respectively), with lower extremity injuries predominating. This approximates the 2006 rate among all DoD personnel (19.2 per 1000 person-weeks) as reported by Jones et al[17] and appears to reflect a decline among Air Force basic trainees since the mid-1990s.[13] However, such comparisons between the studies must be made cautiously due to the large intervening time gap, different injury definitions (ie, the more exhaustive list of *ICD-9-CM* codes used in the present study), and different inclusion and exclusion criteria (eg, use of "brother/sister flights" in the Snedecor et al[14] study). Our dataset, like that of Jones et al,[17] is based on a comprehensive injury definition that includes both acute and overuse injuries and is in accordance with the DoD Military Injury Metrics Working Group.

It appears that sprains, strains, and ruptures (30.5%) and stress fractures (6.6%) were responsible for much larger fractions of injuries among Air Force basic military trainees than among all DoD personnel (2.1% and 2.0%, respectively).[17] Such discrepancies are likely attributable to both real and artifactual differences. First, the greater fraction of sprains, strains, and ruptures during BMT may be largely explained by differences in the BMT environment. With close scrutiny to be sure they are meeting training requirements and a limited ability to self-treat, trainees are probably more likely to request medical care for minor

Table 2. Demographic, Training Outcome, Anthropometric, and Fitness Assessment Data, Stratified by Injured and Uninjured Trainees, Air Force Basic Military Training, July 1, 2012–June 30, 2014[a]

Variable	Injured Trainees		Uninjured Trainees		Prevalence Ratio (95% Confidence Interval)	*P* Value
	n	Mean ± SD or %	n	Mean ± SD or %		
Age, y	8448	22.1 ± 3.3	59 077	21.8 ± 3.0		<.001[b]
Sex						
Female	2862	33.9	11 688	19.8	1.87 (1.79, 1.94)	
Male	5586	66.1	47 389	80.2	Referent	
Graduated Basic Military Training?						
No	1513	17.9	3516	6.0	3.01 (2.85, 3.18)	
Yes	6935	82.1	55 561	94.0	Referent	
Graduated on time?						
No	1364	19.7	3799	6.8	2.88 (2.72, 3.04)	
Yes	5571	80.3	51 762	93.2	Referent	
Days in training	8448	76.9 ± 63.2	59 077	64.8 ± 36.0		<.001[b]
Body mass index[c]						
Women	1924	23.4 ± 2.8	7031	23.5 ± 2.7		.474
Men	3585	23.8 ± 2.8	28 726	24.0 ± 2.7		.009
Abdominal circumference, cm[c]						
Women	1532	72.4 ± 5.3	5868	72.1 ± 5.3		.138
Men	2705	79.8 ± 5.3	24 061	79.8 ± 5.1		.283
Push-up count[c]						
Women	1948	13.5 ± 8.6	7073	15.7 ± 8.9		<.001[b]
Men	3692	33.4 ± 12.7	29 560	36.6 ± 12.3		<.001[b]
Sit-up count[c]						
Women	1948	26.1 ± 11.0	7074	28.7 ± 10.7		<.001[b]
Men	3692	35.7 ± 10.9	29 538	38.2 ± 10.5		<.001[b]
1.5-mi (2.4-km) Run time, min:s[c]						
Women	2793	16:24 ± 2:09	11 466	15:37 ± 2:08		<.001[b]
Men	7316	13:00 ± 1:53	46 725	12:25 ± 1:40		<.001[b]

[a] Missing data were excluded and, therefore, n values are not equivalent.
[b] Indicates difference after Bonferroni correction.
[c] Reflects measurement or score on initial fitness assessment.

acute injuries.[18] An active-duty member is usually subject to less scrutiny, has much more latitude to self-treat minor acute injuries, and thus, often never presents for medical care. The higher incidence of stress fractures during BMT is likely attributable to the relatively high volume of enforced running and marching activities[19] and corresponds with findings from earlier studies[11,20] in military training settings. Of note, the rates for active-duty members are based on a different injury definition; however, because our definition is more inclusive, our denominator is greater and would tend to minimize the actual differences.

Given the relatively high physical demands of BMT and limited access to self-care resources, providing trainees easy access to certified athletic trainers (ATs) within a training unit appears to be a feasible way to reduce the effect of injuries.[21] Increasingly over the past 15 years, ATs have been employed by the Army, Navy, and Marine Corps to prevent injuries and provide early rehabilitation of injuries in military trainees. Although these efforts have received many reports of success and have resonated with commanders,[22–24] published data on the efficacy of ATs in this role are lacking.[25] A prospective controlled trial will soon be conducted at JBSA-Lackland to obtain data on the effectiveness of ATs in increasing on-time graduation rates and decreasing costs related to musculoskeletal injuries.

The negative effect of musculoskeletal injuries in military trainees is largely felt in attrition. A large percentage (17.9%) of injured trainees failed to graduate, and almost 20% of those who eventually completed training did so on a delayed basis. The training-related costs associated with attrition from musculoskeletal injuries are staggering, equaling roughly 4 times the cost of medical care for all injuries. It is notable that only about half of those individuals who had an injury and were discharged from training were ostensibly discharged as a result of their injury, suggesting that injuries may be associated with other causes of attrition from BMT, such as performance or mental or behavioral health concerns. The relationship between musculoskeletal injuries and nonmedical causes of attrition requires further study. Previous investigations[26,27] on the topic have not been stratified by attrition category.

Although an in-depth discussion of injury risk factors is outside the scope of this article, several findings deserve mention. This study reproduces earlier results that female trainees had approximately 2-fold higher rates of injury than male trainees.[9,10,28–30] Our analysis also supports the results of prior researchers who noted that older age[9,28,30] and lower levels of aerobic and muscular fitness[29,31,32] were associated with an increased risk of injury. Intrinsic factors, such as cigarette smoking[9,29,30,32] and menstrual abnormalities,[31] and extrinsic factors, such as total mileage and

Table 3. Musculoskeletal Injury Counts and Totals by Body Region and Type, Air Force Basic Military Trainees, July 1, 2012–June 30, 2014[a]

Body Region	Injury								Grand Total, n (%)
	Fracture	Stress Fracture	Dislocation	Sprains, Strains, and Ruptures	Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement With Neurologic Involvement	Osteoarthrosis	
Vertebral column									
Cervical	0	NA	0	33	65	0	0	0	
Thoracic	4	NA	0	11	30	0	0	0	
Lumbar	1	NA	0	29	475	3	0	3	
Sacrum/coccyx	3	NA	0	9	5	NA	NA	NA	
Spine and back unspecified	1	1	0	2	51	2	1	0	
Total	9	1	0	84	626	5	1	3	729 (6.2%)
Torso									
Chest	1	NA	0	23	NA	NA	NA	NA	
Abdomen	NA	NA	NA	NA	NA	NA	NA	NA	
Pelvis and urogenital	7	NA	0	34	NA	NA	NA	NA	
Trunk	0	NA	NA	NA	NA	NA	NA	NA	
Back and buttock	NA	NA	NA	17	NA	NA	NA	NA	
Total	8	0	0	74	0	0	0	0	82 (0.7%)
Upper extremity									
Shoulder	3	0	18	165	282	22	NA	1	
Upper arm and elbow	0	0	2	6	51	1	NA	0	
Forearm and wrist	7	NA	0	34	144	1	NA	0	
Hand	59	NA	2	46	55	0	NA	0	
Other and unspecified	0	NA	NA	NA	NA	NA	NA	NA	
Total	69	0	22	251	532	24	0	1	899 (7.7%)
Lower extremity									
Hip	6	NA	1	188	476	3	NA	1	
Upper leg and thigh	10	110	NA	0	NA	NA	NA	NA	
Knee	3	NA	18	76	3003	31	NA	9	
Lower leg and ankle	75	385	0	865	1497	11	NA	NA	
Foot and toes	44	70	0	59	809	NA	NA	3	
Other and unspecified	1	NA	NA	1393	NA	NA	NA	NA	
Total	139	565	19	2851	5785	45	0	13	9147 (78.4%)
Unspecified									
Other/multiple	0	2	0	0	17	1	NA	1	
Unspecified site	0	208	1	570	12	0	0	4	
Total	0	210	1	570	29	1	0	5	816 (7.0%)
Grand total, n (%)	225 (1.9%)	776 (6.6%)	42 (0.4%)	3560 (30.5%)	6972 (59.7%)	75 (0.6%)	1 (0.0%)	22 (0.2%)	11673 (100%)

[a] Cells with no corresponding *International Classification of Diseases, Ninth Revision, Clinical Modification* codes were labeled NA, and cells with codes that had zero incident injuries were marked 0.

Table 4. Most Common Musculoskeletal Injury Diagnoses, Air Force Basic Military Trainees, July 1, 2012–June 30, 2014

International Classification of Diseases, Ninth Revision, Clinical Modification Code	Short Description	n
719.46	Pain in joint, lower leg[a]	2984
844.9	Sprains and strains of unspecified site of knee and leg[b]	1273
719.47	Pain in joint, ankle, and foot	1240
845.00	Ankle sprain, unspecified site	747
719.45	Pain in joint, pelvic region, and thigh	475

[a] Includes patellofemoral pain syndrome.
[b] Includes shin splints.

training intensity,[18,33] have also been shown to contribute to injury risk but were not evaluated in this study. Shoe prescriptions based on plantar shape or modifications to the training environment (eg, rubberized tracks) have been instituted at Air Force BMT as a means of preventing injury, but previous investigations[34–36] did not support their effectiveness.

The findings of this study should be interpreted in light of its limitations. Most important, the reported incidence rate may not reflect the true rate of new injuries. First, we relied on a retrospective review of *ICD-9-CM* diagnoses made by multiple medical providers, each perhaps affected by personal biases and practice preferences. Furthermore, miscoded or omitted diagnoses affect data accuracy, and it was not feasible to conduct chart reviews for all cases. Second, some injuries may have existed before BMT; these would technically be prevalent, rather than incident, cases of injury. Third, physical fitness data were missing for a number of trainees, likely due to the failure to complete all components of the assessment. Finally, a stringent definition of *incident injury* was used to avoid counting more than 1 injury when a trainee had multiple medical encounters for the same injury. However, this method carries the risk of counting separate injuries as one. Nevertheless, this favors the null hypothesis and reduces the chance of a type I error.

This study benefits from a large dataset of a well-defined population over a delineated surveillance period. By using a previously published injury matrix[15] (with minor modifications) that accounts for both body region and injury type, our coding system minimized misclassification bias and double counting of injuries. Furthermore, this robust and comprehensive coding system allowed for better capture of all injuries, rather than focusing on either acute (see Barell et al[37] matrix) or overuse injuries.[38]

Although injury rates during US Air Force BMT appear to be declining, our findings suggest that musculoskeletal injuries remain a major contributor to morbidity, missed training time, discharges, and fiscal burden. Preventive and rehabilitative efforts should focus on the lower extremities and particularly overuse injuries, stress fractures, and sprains, strains, and ruptures. New initiatives in US Air Force BMT, such as embedding ATs within a training squadron and establishing a clinical algorithm for the evaluation of bone-stress injuries, should be analyzed to assess their effects on operational, fiscal, and health outcomes. When possible, robust experimental studies should be prioritized over observational study designs.

DISCLAIMER

The opinions expressed in this document are solely those of the authors and do not represent an endorsement by or the views of the US Air Force, the DoD, or the US government.

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