Factors Associated with Lower Extremity Training-Related Injuries Among Enlisted Women in U.S. Army Operational Units

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Abstract

Background: The lower extremity is consistently the most injured body region among U.S. Army soldiers. However, there has been limited research on risk factors for lower extremity injuries, particularly among women.

Purpose: The purpose of this investigation was to assess factors associated with lower extremity training-related injuries among enlisted women from two Army light infantry brigades.

Materials and Methods: Female U.S. Army soldiers (n=369) completed a survey, including questions on personal characteristics, physical fitness, and physical training (PT). Medical encounter data were obtained from the Defense Medical Surveillance System and analyses were limited to training-related lower extremity injuries.

Results: In total, 54.7% (n=202) of women experienced one or more injuries in the previous 12-month period; more specifically, 27% (n=100) of women sustained a lower extremity training-related injury. Higher injury incidence was associated with "heavy" occupational physical demand, low muscular endurance (sit-ups), performing resistance training during unit PT, mileage for personal PT runs, and not performing interval training for personal PT. In the multivariable analysis, greater frequency of resistance training during unit PT was associated with a higher incidence of lower extremity training-related injury (OR: 1.75, 95% CI: 1.01-3.01, p=0.05) and lower frequency of interval training during personal PT was associated with a higher incidence of lower extremity training-related injury (OR: 2.08, 95% CI: 1.17-3.68, p=0.01).

Conclusion: While prospective studies are needed, results suggest that ensuring recommended guidelines for resistance training are followed during unit physical training and adding interval training to personal training routines may lower risk of lower extremity training-related injury among female soldiers.

Key Words: women, military, occupational, injuries, physical training

Introduction

In 2012, almost 14% of U.S. Army soldiers were women.[1] With the opening of combat arms occupations to women, female soldiers who choose to enter these military occupational specialties (MOS's) will face a variety of new roles and potential injury risks.[2] Given the physically-demanding nature of many military occupations, it is important to investigate differences in injury rates and risk factors between men and women.[3]

Several factors have been associated with risk of any injury among women in the military: low physical fitness (as measured by Army Physical Fitness Test (APFT) scores and/or peak VO_2 max),[4-6] higher body fat percentage (≥ 23.7%),[5] history of injury,[7] not participating in unit runs,[7] and participating in personal resistance training sessions once or twice a week compared to no personal resistance training.[7] Much of the research on these risk factors has been conducted among soldiers in controlled training environments where all soldiers perform the same activities.

Previous studies that have not controlled for fitness have found women in the military experience higher rates of injury than men (18% to 70% higher).[8] However, risk of injury is often confounded by physical fitness level. Studies that control for physical fitness level have found there is no difference in injury risk between male and female soldiers,[3, 4, 9] i.e., men and women of similar fitness levels have similar risks of injury.

In military populations, the lower extremity is consistently the most injured body region.[6, 9-12] Previous studies suggest that lower extremity injuries account for 28% to 85% of all injuries in military populations.[6, 9, 11, 12] There has been limited investigation of risk factors for lower extremity injuries, in particular among female soldiers. The purpose of this study was to determine the association of personal characteristics, physical fitness, and physical training factors with lower extremity training-related injury among enlisted female US Army soldiers.

Materials and Methods

Surveys were completed by US Army as part of an ongoing evaluation of a physical training program. Subjects for this analysis were enlisted (E1-E9) female soldiers from two light infantry Army brigades. The brigades consisted of six battalions: infantry, cavalry, field artillery, brigade support, brigade special troops battalion, and headquarters. At the time of data collection (2010-2011), women were eligible to serve in non-combat occupations only. The project was reviewed and approved by the U.S. Army Public Health Center Public Health Review Board.

The paper survey obtained information on the soldiers' personal characteristics, including their current height and weight, most recent APFT scores, unit PT participation, and personal PT participation. BMI was calculated from self-reported height (m) and weight (kg) (kg/m^2). If self-reported data were missing, height and weight were extracted from unit records where available. BMI was categorised according to the Centers for Disease Control and Prevention (CDC) classifications for "underweight" (≤ 18.5 kg/m^2), "normal" (18.5 – 24.9 kg/m^2), "overweight" (25.0 – 29.9 kg/m^2) and "obese" (≥ 30.0 kg/m^2).[13] The "overweight" category was split into two categories: "low overweight" (25.0 – 27.4 kg/m^2) and "high overweight" (27.5 – 29.9 kg/m^2).[14] The "underweight" and "normal" categories were condensed into one "normal" category due to a small number of underweight soldiers. Body fat percentage was estimated from BMI, age, and gender using the following equation: body fat percentage = (1.20 x BMI) + (0.23 x age) – (10.8 x sex) – 5.4, where sex=0 when female.[15] Current cigarette smokers were identified as those who had smoked at least 100 cigarettes in their lifetime and smoked at least one cigarette in the previous 30 days from the survey administration date, consistent with the CDC current smoker definition.[16]

Military occupational specialties (MOSs) were grouped by occupational structure and assigned a physical demand level.[14] Physical demand levels were categorised as "Very Heavy" (constant lifting in excess of 50 pounds (lbs.) or occasional lifting over 100 lbs.), "Heavy" (constant lifting of 50 lbs. or occasional lifting maximum of 100 lbs.), "Moderately Heavy" (constant lifting of 40 lbs. or occasional lifting maximum of 80 lbs.), "Medium" (constant lifting of 25 lbs. or occasional lifting maximum of 50 lbs.), or "Light" (constant lifting of 10 lbs. or occasional lifting maximum of 20 lbs.).[17] The "Medium" and "Light" MOS groups were consolidated into "Medium-Light" due to small numbers.

Physical fitness was measured by self-reported performance on the most recent Army Physical Fitness Test (APFT). The APFT consists of a timed (2 minute) push-up event, a timed (2 minute) sit-up event, and a two-mile run for time.[18] If self-reported data were missing, the APFT measures were extracted from unit records where available. APFT scores were converted into tertiles (T) where T3 = lowest one third (33%) performance and T1 = highest one third (33%) performance.[6, 18] Predicted VO_2max was estimated from two-mile run times using the Mello formula as follows: predicted VO_2max = 72.9-(1.77 x (two-mile run time)).[19] High correlations have been found between actual APFT performance and self-reported APFT performance as well as actual and self-reported height and weight among soldiers in operational units.[20] Unit PT survey questions included frequency and duration of the following performed in the last 6 months: cross-training, distance running, sprint or interval training (henceforth "interval training"), calisthenics, resistance training, agility drills, and road marches. Personal PT survey questions included current frequency and duration of the following: distance running, resistance training, and interval training. Cross-training was defined as a program that involves a variety of exercises, such as strength training, agility drills, sprints, plyometrics, etc.; distance running was defined as running continuously for 1 mile or greater; sprints were defined as short bursts of speed that cannot be sustained for more than a few minutes; intervals were defined as short periods of high speed running mixed with periods of jogging or walking; calisthenics were defined as jumping jacks, windmills, mountain climbers, etc.; resistance training was defined as weight lifting using free weights, dumbbells, kettlebells, hammer-strength machines, etc.

Medical encounter data were obtained from the Defense Medical Surveillance System (DMSS), a data system maintained by the Armed Forces Health Surveillance Branch (AFHSB) containing all records of inpatient and outpatient medical encounters at military treatment facilities or paid for by the military health system.[21] Medical encounter data included race, visit dates, and International Classification of Diseases 9th Revision Clinical Modification (ICD-9-CM) diagnosis codes for all outpatient and hospitalised injury medical encounters for the 12 months before survey administration and fitness testing. Injuries were identified using the primary (first) diagnosis. Injuries included ICD-9-CM codes associated with both overuse and traumatic injuries, consistent with prior studies of injuries in military populations.[7, 14, 22, 23] Selected lower extremity injuries commonly due to overuse during military training have been monitored as part of ongoing Army training-related injury reports since 2003[24]; this injury definition was used for this analysis. Diagnoses included sprains and strains, tendinitis, lumbago, and joint pain; body parts included lower back, hips, pelvis, leg, knee, ankle, and foot. See Appendix A for a list of specific ICD-9-CM codes.

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), Version 19.0. Summary statistics for categorical variables include frequencies and percentages. Summary statistics for continuous variables include means and standard deviations. Univariate logistic regression was employed to calculate unadjusted odds ratios and 95% confidence intervals (95% CIs) to assess the association of personal characteristics, physical fitness, unit physical training, and personal physical training with injury risk. Provided there were sufficient data, the variable level with the lowest injury risk was selected as the referent group and was used to compare the injury risk at other variable levels. To identify independent predictors of injury risk, variables with a $p \leq 0.10$ in univariate logistic regression models were included in a backward elimination multivariable logistic regression model. Odds ratios and 95% CIs are presented for the final multivariable logistic regression model. Variables with a $p \leq 0.05$ were considered significantly associated with lower extremity training-related injuries in the multivariable model.

Results

There were 369 enlisted female soldiers in the two brigades, who had an average age of 29.9 ± 6.1 years (range: 22 to 52 years) and average BMI of 24.7 ± 3.1 kg/m^2 (normal). The highest proportion of women were Caucasian (35%), in combat service support MOS's (67%), in occupations with very heavy (37%) or moderately heavy (31%) occupational physical demand ratings, and were not current smokers (66%) (Table 1). A majority of women reported participating in both unit physical training (93%) and personal physical training (77%).

Table 1. Personal characteristics of enlisted female US Army soldiers in two light infantry brigades (n=369)

Variable	Categories	Total n (%)
Age (Years)	22-26	138 (37.4)
	27-31	124 (33.6)
	≥ 32	107 (29.0)
Race/Ethnicity	Caucasian	130 (35.2)
	Black	83 (22.5)
	Hispanic	56 (15.2)
	Unknown/Other	100 (27.1)
Battalion	Brigade Support Battalion	141 (38.2)
	Special Troops Battalion	128 (34.7)
	Infantry	32 (8.7)
	Armor	29 (7.9)
	Cavalry	17 (4.6)
	Field Artillery	16 (4.3)
	Headquarters	6 (1.6)
MOS	Combat Arms	0 (-)
	Combat Support	120 (32.7)
	Combat Service Support	246 (67.3)
Occupational Physical Demand Level	Very Heavy	134 (36.6)
	Heavy	101 (27.6)
	Moderately Heavy	112 (30.6)
	Medium-Light	19 (5.2)
BMI (kg/m^2)	Normal (< 25.0)	198 (55.2)
	Low Overweight (25.0 – 27.4)	98 (27.3)
	High Overweight (27.5 – 29.9)	43 (12.0)
	Obese (≥ 30.0)	20 (5.6)
Body Fat Percentage (Tertiles)	≤ 29.05	116 (32.3)
	29.06-32.50	123 (34.3)
	≥ 32.51	120 (33.4)

Table 2. Association of personal characteristics, physical training, and physical fitness with lower extremity training-related injury, enlisted female US Army soldiers in two light infantry brigades (n=369)

Variable	Categories	n	Injured (%)	Odds Ratio (95% CI)	Uncorrected X^2 p-value
Race/Ethnicity	Caucasian	130	26.2	1.28 (0.66-2.46)	0.46
	Black	83	21.7	1.00	
	Hispanic	56	23.2	1.09 (0.49-2.46)	0.83
	Unknown/Other	100	35.0	**1.94 (1.00-3.78)**[*]	**0.05**
Occupational Physical Demand Level	Very Heavy	134	23.9	1.00	
	Heavy	101	36.6	**1.84 (1.05-3.25)**	**0.03**
	Moderately Heavy	112	25.0	1.06 (0.59-1.90)	0.84
	Medium-Light	19	11.8	-	-
APFT[†] Sit-Ups (Repetitions)	Lowest Performing Two-Thirds (< 69)	222	28.8	**1.68 (0.96-2.93)**	**0.07**
	Highest Performing Third (≥ 69)	108	19.4	1.00	
Unit PT[‡] Resistance Training Frequency (per Week)	Do not perform / < 1 time per week	252	22.6	1.00	
	≥ 1 time per week	107	36.4	**1.96 (1.20-3.21)**	**< 0.01**
Personal PT[‡] Average Distance per Run (Miles)	Did not perform / 1 mile	185	31.4	**1.57 (0.98-2.52)**	**0.06**
	> 1 mile	173	22.5	1.00	
Personal PT[‡] Interval Training Frequency (per Week)	Did not perform / < 1 time per week	233	30.5	**1.64 (1.00-2.71)**	**0.05**
	≥ 1 time per week	133	21.1	1.00	

Note: The following variables were tested and not significantly associated with lower extremity training-related injury (p>0.10): Age, Battalion, MOS, BMI, Body Fat Percentage, Smoking Status, APFT Push-Ups, APFT 2 Mile Run Time, Unit PT Distance Run Frequency, Unit PT Average Distance Per Run, Unit PT Sprint/Interval Training Frequency, Unit PT Road Marching Frequency, Unit PT Average Distance Per March, Personal PT Distance Runs Frequency, Personal PT Resistance Training Frequency

[*] *Bold indicates p≤0.10 and included in multivariable model*

[†] *Army Physical Fitness Test*

[‡] Physical training

In total, 55% (n=202) of women experienced one or more injuries in the previous 12-month period. Of those who were injured, 50% (n=100) sustained a lower extremity training-related injury. Of the lower extremity training-related injuries, 76% (n=76) were classified as musculoskeletal conditions (ICD-9-CM codes 710-739) and 24% (n=24) were classified as traumatic injuries (ICD-9-CM codes 800-999).

Odds ratios for variables possibly associated with lower extremity training-related injury are found in Table 2. Higher unadjusted odds of injury (p≤0.10) was associated with unknown/other race, “heavy” occupational physical demand, low APFT sit-up performance, resistance training one or more times per week for unit physical training, not performing or only completing an average of 1 mile for personal

Table 3. Unit PT, personal PT, and personal characteristics risk factors for lower extremity training-related injury among enlisted female US Army soldiers using multivariable logistic regression (n=295)

Variable	Categories	n	Odds Ratio (95% CI)	p-value
Unit PT* Resistance Training Frequency (per Week)	Do not perform / < 1 time per week	202	1.00	
	≥ 1 time per week	95	1.75 (1.01-3.01)	**0.05**
Personal PT* Interval Training Frequency (per Week)	Did not perform / < 1 time per week	183	2.08 (1.17-3.68)	**0.01**
	≥ 1 time per week	114	1.00	
Variables entered into the model (p<0.10 in unadjusted models):				
Race/Ethnicity	Unit PT* Resistance Training Frequency per Week			
Physical Demand	Personal PT* Average Distance Per Run			
APFT† Sit-Ups	Personal PT* Sprint / Interval Training Frequency			

* *Physical Training*

† *Army Physical Fitness Test*

physical training runs, and not performing interval training or performing interval training less than once per week for personal physical training. The unadjusted odds ratio was not calculated for the “medium-light” occupational physical demand group due to the low count. The two lowest performing tertiles in each of the APFT measures were combined due to similar odds of injury.

Table 3 displays the results of a backward elimination multivariable logistic regression analysis that examined factors associated with lower extremity training-related injuries related to personal characteristics, unit physical training, and personal physical training. Variables entered into the model included: race/ethnicity, occupational physical demand, APFT sit-up performance, unit PT resistance training frequency per week, personal PT average distance run, and personal PT interval training frequency per week. Variables that remained statistically significantly associated with injury ($p \leq 0.05$) are reported. Resistance training one or more times per week was associated with nearly double the odds of lower extremity training-related injury compared to those who did not perform resistance training or who performed it less than once per week (OR: 1.75, 95% CI: 1.01-3.01, p=0.05). Not performing interval training or performing interval training less than one time per week during personal PT was associated with twice the odds of lower extremity training-related injury compared to those who performed interval training one or more times per week during personal PT (OR: 2.08, 95% CI: 1.17-3.68, p=0.01).

Post hoc descriptive analysis of the enlisted female soldiers included in the unit and personal physical training regression models are shown in Table 4. Overall, women who participated in unit resistance training one or more times per week appear to be less physically fit based on measures of body composition, but were no different with regard to push-up, sit-up, run time performance, or estimated VO_2max. Female soldiers who did not incorporate interval training into their personal PT program or who did so less than once per week performed fewer push-ups and sit-ups than those who conducted interval training once or more per week.

Discussion

In these operational units, 27% of female soldiers experienced a lower extremity training-related injury in the previous 12 months. Considering a variety of personal characteristics, physical fitness, and physical training, this study indicated that resistance training one or more times per week for unit PT was associated with lower extremity training-related injuries among women. Lack of interval training or performance of interval training less than once per

Table 4. Personal characteristics and physical fitness among enlisted female soldiers in the multivariable model (n=297)

Variable	Unit PT* Resistance Training Frequency		T test p-value†	Personal PT* Interval Training Frequency		T test p-value†
	Do not perform and < 1 time per week	≥ 1 time per week		Do not perform and < 1 time time per week	≥ 1 time per week	
BMI (kg/m²)	24.4 ± 2.9 (n=197)	25.4 ± 3.1 (n=92)	**0.01**‡	24.7 ± 3.0 (n=180)	24.8 ± 3.0 (n=109)	0.78
Body Fat Percentage	**30.6 ± 3.9 (n=197)**	**32.1 ± 4.3 (n=92)**	**0.01**	30.8 ± 4.07 (n=180)	31.1 ± 4.2 (n=109)	0.99
APFT§ Push-Up (repetitions)	38.0 ± 11.7 (n=198)	36.9 ± 11.5 (n=92)	0.46	**36.5 ± 11.8 (n=178)**	**39.5 ± 11.2 (n=112)**	**0.03**
APFT§ Sit-Up (repetitions)	63.5 ± 12.8 (n=202)	63.3 ± 11.3 (n=95)	0.92	**62.3 ± 11.6 (n=183)**	**65.3 ± 13.2 (n=114)**	**0.04**
APFT§ 2-mile Run (minutes and fraction of a minute)	18.26 ± 2.0 (n=179)	17.87 ± 2.2 (n=83)	0.17	18.31 ± 2.1 (n=154)	17.89 ± 2.0 (n=108)	0.11
Estimated VO_2max	40.6 ± 3.6 (n=179)	41.3 ± 3.8 (n=83)	0.17	40.5 ± 3.8 (n=154)	41.2 ± 3.6 (n=108)	0.11

* *Physical training*

† *Assuming equal variances*

‡ *Bold indicates p≤0.05*

§ *Army Physical Fitness Test*

week during personal PT was also associated with lower extremity training-related injury. Previous studies of initial entry military populations have usually found that low physical fitness among women and men is a primary risk factor for injury, so the finding that physical training is a stronger risk factor among women in operational units offers an important new insight.

The personal characteristics of the population under study were similar to that of previous investigations of female soldiers.[3-5, 7, 9, 12] Other investigations of women reporting the incidence of lower extremity training-related injuries vary from 9.8% to 36%.[12, 25] The lower extremity training-related injury incidence in this study is lower than the rate among U.S. Army female wheel vehicle mechanics, though only 43 female wheel mechanics were screened.[12] Female soldiers of the 1st Cavalry Division experienced an incidence of 9.8% to 11.8% lower extremity training-related injuries prior to their 2006 deployment to Iraq, while post-deployment, the women experienced lower extremity training-related injury incidence between 22.4% and 28%.[25] The lower injury incidence among women in the 1st Cavalry Division prior to deployment may be attributed to unmeasured factors such as different physical training or MOS duties than those in the current study, given that the same lower extremity training-related injury definition was used.

Resistance training has previously been found to be a protective factor against injury among male soldiers[22] and to increase female soldiers' performance on combat-related tasks,[26] however, this study found that resistance training for women was a risk factor. Roughly 30% of the women who participated in this investigation performed resistance training with their units, and it may be that the resistance training itself caused injuries.

Resistance training is important to build lean mass and muscle strength in women,[26] but women may have a different risk for musculoskeletal injuries from resistance training than men due to physiologic differences.[27] Women in their twenties have higher body fat relative to their mass compared with men (20-25% compared with 13-16% for men) and they also have approximately 30% less lean body mass than males.[27] Differences in body composition can mean different performance abilities in the context of an MOS, as men generally have greater absolute muscular endurance and power.[27] A study by Roy *et al.* indicated that female soldiers who participated in resistance training 1 to 2 times per week were at a greater risk for any injury compared to those who did not perform resistance training.[7] Roy *et al.* also demonstrated there was an upside down U-shaped relationship between resistance training and risk of injury among women in the military, because those who did not perform any personal weight training for 3 or more sessions a week were neither significantly protected nor harmed.[7] The current study is the first to identify an association between resistance training (e.g. weight lifting using free weights, dumbbells, kettlebells, hammer-strength machines, etc.) and lower extremity injury among female soldiers.

Soldiers may reduce the risk of injuries during resistance training by following training regimens such as the RESET, TRAIN, and READY phases described in the US Army "Building the Soldier Athlete" manual.[28] By focusing on resistance training form, gradually increasing intensity, and ensuring adequate rest and recovery, soldiers can prevent training-related lower extremity injuries.[28] Field Manual 7-22 "Army Physical Readiness Training" also recommends training schedules and resistance training drills that allow leaders to adapt physical readiness training to occupational requirements.[18]

Women who did not perform interval training as part of their personal exercise routines or performed interval training less than once per week had a higher risk of lower extremity training-related injuries than those who performed interval training one or more times per week for personal PT. Interval training appears to be a marker for fitness in general, as evidenced by the women who perform interval training one or more times per week having higher APFT push-up and sit-up scores on average than those who did not perform interval training. Low levels of physical fitness have previously been associated with higher injury risk in other military populations,[6, 8] so it may be that interval training is a marker for a more intense personal training regimen leading to higher fitness levels which may be protective.

Other studies have found associations between interval training, fitness, and injury. A study of male US Air Force servicemen tested the association of interval training and injury by replacing approximately half of traditional running with interval running and agility training during the combat controller training program.[29] The authors attributed an increase in soldier fitness (e.g. VO_2max and time-to-exhaustion) and 67% decrease in overuse injuries to the use of interval training instead of distance running.[29] This is similar to the findings of the current study, where women who did not perform interval training sustained a higher risk of lower extremity injury. A study of female soldiers from the Combat Fitness Instructor Course of the Israel Defense Forces found that injured soldiers tended to have slower initial 10 metre sprint times than soldiers who did not report any injury.[5] Though this Israel Defense Forces study did not find that sprint time predicted injury, it demonstrates the potential relationship between lack of interval training (with slower sprint time as a proxy measure) and risk of injury in a female military population.

Prior research has shown that the least fit soldiers, regardless of gender, are at the highest risk for injury.[3, 4, 9] While not statistically significant with two-tailed chi square tests, this study nevertheless found that women who performed in the lowest two-thirds of APFT events (sit- ups, push-ups, and two-mile run) had higher risks of lower extremity training-related injury than the highest performing one-third. The directionality of the findings regarding fitness measured by push-ups, sit ups, and two-mile run time from this study are consistent with the literature.[4, 6, 22, 24]

Additionally, women in MOS's with "heavy" physical demands had higher risk of injury before controlling for other factors. A previous study of male soldiers found an association between heavier physical demands and musculoskeletal hospitalisation.[30] Physical demands are related to load lifted, and Roy *et al.* have found that higher frequency of lifting objects and higher height of objects lifted were associated with injury among a population of deployed soldiers.[10] The lack of association between job physical demands and lower extremity training-related injury in the multivariable model in the current study may be due to lack of power; therefore, future analyses would benefit from greater sample sizes.

There were some limitations in this investigation. Twenty percent of women were of "unknown/other" race/ethnicity, suggesting a need to improve recording of race/ethnicity in the medical records data. Injury data and physical training behaviours were simultaneously assessed in this study; therefore the causality of injury was unable to be determined. It is possible that women reporting resistance training at least once per week were already on profile, unable to perform aerobic exercise, and were executing reconditioning programs involving strength training as described in US Army physical training doctrine.[18] The higher BMI and body fat percentage seen in those reporting resistance training may be a result of limited ability to perform aerobic exercise. Future studies should investigate resistance training as an injury risk factor for female soldiers prospectively.

Personal characteristics, physical fitness, and physical training data were self-reported by survey, which can be subject to recall bias as well as concerns about honesty in answers and lack of comprehension of the questions. However, prior analyses have found high correlations between actual and self-reported height, weight, and APFT data[20] in US Army personnel in operational units. In this analysis, body fat percentage was estimated using the Deurenberg formula, which has been found to have less than 2% mean difference between reported and predicted body fat percentage.[15] Even though the Deurenberg formula[16] is validated with regard to its accuracy, it remains an estimation tool only. In addition, CDC BMI cut points may not be appropriate for all persons due to evidence showing varying correlations between BMI, percentage of body fat, and body fat distribution among different ethnicities.[13] Use of electronic medical records ensured that all injuries receiving medical treatment from within and outside the Military Health System were captured; however, minor injuries are likely underestimated. Use of external cause of injury coding in the medical records was not sufficient to provide information on the activity associated with the injury or the mechanism of injury, and therefore could not be reported. Future studies would benefit from inclusion of injury history, more detailed assessment of training volume and progression, and a prospective review of injuries relative to risk factors.

This study suggests that physical training levels are more significantly associated with injury than personal characteristics and fitness level among women in operational units. Lower extremity training-related injury was associated with more exposure to resistance training and less exposure to interval training. Resistance training is recommended at least 2 to 3 times per week for soldiers.[28] Soldiers may benefit from additional guidance to ensure proper resistance training technique. With more instruction, women who perform more resistance training might not have a higher injury risk than those who do not perform resistance training. Interval training has previously been associated with increased fitness and lower injury risk,[5, 29] and it is recommended that soldiers conduct interval training at least once per week.[28]

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Appendix A: ICD-9-CM codes included as lower extremity training-related injuries[23]

ICD-9-CM Code	Type of injury
717.7	Chondromalacia of patella
719.00	Effusion of joint, site unspecified
719.05	Effusion of joint, pelvic region and thigh
719.06	Effusion of joint, lower leg
719.07	Effusion of joint, ankle and foot
719.08	Effusion of joint, other specified sites
719.09	Effusion of joint, multiple sites
719.40	Pain in joint, site unspecified
719.45	Pain in joint, pelvic region and thigh
719.46	Pain in joint, lower leg
719.47	Pain in joint, ankle and foot
719.48	Pain in joint, other specified sites
719.49	Pain in joint, multiple sites
724.2	Lumbago
724.5	Backache, unspecified
724.9	Other unspecified back disorders
726.5	Enthesopathy of hip region
726.6	Enthesopathy of knee
726.60	Enthesopathy of knee, unspecified
726.61	Pes anserinus tendinitis or bursitis
726.62	Tibial collateral ligament bursitis
726.63	Fibular collateral ligament bursitis
726.64	Patellar tendinitis
726.65	Prepatellar bursitis
726.69	Other enthesopathy of knee
726.7	Enthesopathy of ankle and tarsus
726.70	Enthesopathy of ankle and tarsus, unspecified
726.71	Achilles bursitis or tendinitis
726.72	Tibialis tendinitis
726.73	Calcaneal spur
726.79	Other enthesopathy of ankle and tarsus
726.8	Other peripheral enthesopathies
726.9	Unspecified enthesopathy
726.90	Enthesopathy of unspecified site
726.91	Exostosis of unspecified site
727.2	Specific bursitides often of occupational origin
727.3	Other bursitis
727.65	Nontraumatic rupture of quadriceps tendon
727.66	Nontraumatic rupture of patellar tendon
727.67	Nontraumatic rupture of achilles tendon
727.68	Nontraumatic rupture of other tendons of foot and ankle
728.71	Plantar fascial fibromatosis
729.1	Myalgia and myositis, unspecified
733.10	Pathologic fracture, unspecified site
733.14	Pathologic fracture of neck of femur
733.15	Pathologic fracture of other specified part of femur
733.16	Pathologic fracture of tibia or fibula
733.19	Pathologic fracture of other specified site
733.60	Tietze's disease
733.93	Stress fracture of tibia or fibula
733.94	Stress fracture of the metatarsals
733.95	Stress fracture of other bone
843	Sprains and strains of hip and thigh
843.0	Iliofemoral (ligament) sprain
843.1	Ischiocapsular (ligament) sprain
843.8	Sprains and strains of other specified sites of hip and thigh
843.9	Sprains and strains of unspecified site of hip and thigh
844.0	Sprain of lateral collateral ligament of knee
844.1	Sprain of medial collateral ligament of knee
844.2	Sprain of cruciate ligament of knee
844.3	Sprain of tibiofibular (joint) (ligament) superior, of knee
844.8	Sprains and strains of other specified sites of knee and leg
844.9	Sprains and strains of unspecified site of knee and leg
845	Sprains and strains of ankle and foot
845.0	Ankle sprain
845.00	Sprain of ankle, unspecified site
845.01	Sprain of deltoid (ligament), ankle
845.02	Sprain of calcaneofibular (ligament) of ankle
845.03	Sprain of tibiofibular (ligament), distal of ankle
845.09	Other sprains and strains of ankle
845.1	Foot sprain
845.10	Sprain of foot, unspecified site
845.11	Sprain of tarsometatarsal (joint) (ligament) of foot
845.12	Sprain of metatarsophalangeal (joint) of foot
845.13	Sprain of interphalangeal (joint), toe
845.19	Other sprain of foot
846	Sprains and strains of sacroiliac region
846.0	Sprain of lumbosacral (joint) (ligament)
846.1	Sprain of sacroiliac ligament
846.2	Sprain of sacrospinatus (ligament)
846.3	Sprain of sacrotuberous (ligament)
846.8	Sprain of other specified sites of sacroiliac region
846.9	Sprain of unspecified site of sacroiliac region
847.2	Sprain of lumbar
847.3	Sprain of sacrum
847.4	Sprain of coccyx
847.9	Sprain of unspecified site of back
848.5	Sprain of pelvic
848.8	Other specified sites of sprains and strains
848.9	Unspecified site of sprain and strain

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