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## U.S. Coast Guard Academy Injury and Risk Factor Study

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Author LMC wrote the manuscript and managed the literature searches. Author KLR designed the study and was the medical advisor to the study. Author RSS assisted in designing the study and collected the data. Author JJK performed the statistical analysis and advised with editing. Author WI assisted with the study design and establishing the database. All authors read and approved the final manuscript.*

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### ABSTRACT

**Purpose:** Injury rates and injury risk factors were examined for the first time among cadets undergoing Summer Warfare Annual Basic (SWAB) training at the U.S. Coast Guard Academy (USCGA).

**Methods:** Participants were 778 men and 286 women from four years of SWAB training. Before SWAB training, the subjects were administered a Physical Fitness Assessment (PFA) (2-minute maximal effort sit-ups and 1.5 mile run) and functional movement screening (FMS) test. Height and weight were measured and, gender, age and ethnicity were obtained from administrative records. Training-related injuries were compiled from student medical records. The diagnosis, body part location, disposition, and limited duty days were recorded for each clinic visit.

**Results:** During the 8 weeks of SWAB training, 23.8% of the women and 18.4% of the men were injured at least once. Compared to the men, the odds of an overall injury

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among women was 1.39 (95% confidence interval= 1.00-1.92). The odds of an overuse injury among women was 1.72 (95%confidence interval= 1.21-2.43) times higher than the men and the number of limited duty days for overuse injuries was also higher among the women ( $p < 0.01$ ). Independent risk factors for injuries among both men and women included lower aerobic fitness and lower functional movement screening scores.

**Conclusions:** Female USCGA cadets were at higher risk of injuries, especially overuse-type injuries. Specific factors that put cadets at higher injury risk included lower aerobic capacity and inefficient movement strategies. Future injury studies should focus on females, aerobic fitness, and movement strategies. Prevention strategies should be tested to reduce injuries to limit lost training time.

*Keywords: Physical fitness; functional movement screening; sit-ups; 1.5-mile run.*

## 1. INTRODUCTION

Each year, United States Coast Guard (USCG) cadets undergo 8 weeks of Summer Warfare Annual Basic (SWAB) Training at New London, Connecticut at the beginning of their first year of service. Anecdotal reports from USCG medical staff and training personnel suggested that female cadets were experiencing higher injury rates than male cadets. Prior military studies consistently show that women incur about twice the injury rate of men in Basic Combat Training [1-5]. No previous studies have been published on injuries among USCG recruits undergoing SWAB training. Both BCT and SWAB training represent opportunities to investigate gender-related injury issues under conditions where environmental exposures and physical training programs are essentially identical for men and women<sup>4</sup>. Both women and men perform all training activities together and have similar living conditions. This degree of standardization is difficult to achieve in civilian environments. The primary objective of this study was to compare men and women participating in SWAB training on injury incidence, types of injuries, anatomical location of injuries, and the number of limited duty days (LDDs) that these injuries incurred. A secondary purpose was to examine potential risk factors for injuries in this cohort.

## 2. MATERIALS AND METHODS

### 2.1 Study Design and Participants

This was a prospective investigation of training-related injuries among freshmen cadets participating in SWAB training at the USCGA. Over a 5-year period, 4 classes of incoming cadets (approximately 1200 cadets total) were briefed on the purposes and risks of the investigation. However, not all volunteers completed all parts of the investigation because of other duty-related obligations as well as personnel and equipment limitations. Additionally the first class was excluded from the study since they did not have complete Physical Fitness assessment (PFA) data. The final study sample included 778 men and 286 women. The study started with the first class briefing in July 2003 and the last class completed SWAB training in September 2007. Institutional approval for human subjects' experimentation was given by the USCGA.

## **2.2 SWAB Training**

SWAB training was 8 weeks in length. It was designed to help civilian students acquire specific Coast Guard proficiencies and knowledge and transition into the lifestyle of a United States (US) Coast Guard officer. The training process began by improving physical fitness and developing critical military skills. The training continued with seamanship, swimming, and academics. The cadets trained in 8 companies which were gender specific and further divided into squadrons, generally three per company. Each squadron lived in the same barracks. All cadets in the study remained with the original company for the duration of the training. No significant structural changes in SWAB training have been implemented within the last 15 years.

Table 1 shows the physical training program in which all cadets participated. Emphasis was on cardiorespiratory training (running and marching), resistance/muscle endurance training, and flexibility. Other military training involving physical activities included obstacle courses, rope course challenges, and a cruise on the USCGC Eagle, one of only two active commissioned sailing vessels in the United States military service.

A PFA was conducted at the start and end of the SWAB training. During the study period, the USCGA PFA underwent several changes. Prior to 2005, the PFA consisted of cadence push-ups for two minutes, sit-ups for two minutes, and a 1.5 mile run. Beginning in 2005, the PFA consisted of cadence push-ups for 1 minute, sit-ups for two minutes, and a 1.5 mile run. Because of this change, push-ups were not considered in the analyses of the PFA data. For the sit-up, a recruit started in the supine position with knees bent at a 90° angle, arms crossed across the chest and touching the opposite shoulder, and a second person held the participant's ankles, keeping his feet firmly on the ground. The recruit raised his upper body to a vertical position touching the elbows with the thighs and shoulders are brought back down to the ground before beginning to rise again. The 1.5-mile run was performed on a rubberized indoor or outdoor track and the time to complete the distance was recorded.

## **2.3 Injury Data**

A physical therapist that was part of the research staff diagnosed SWAB training-related injuries and recorded the information in the cadets' medical records. At the end of each SWAB training cycle, a physical therapist and other health care providers who were not part of the study screened the medical records and recorded injuries related to the SWAB training. If a cadet had multiple injuries, then all injuries were recorded separately. Information transcribed included day of visit, verbatim diagnosis, body part, and disposition. The physical therapy staff issued a limited duty status for injuries which included profiles such as: "no running", "no upper body", "no marching", "quarters", and "hospitalization". A training injury was defined as any musculoskeletal or dermatological complaint that resulted in a clinic visit and that was suspected to have been caused by SWAB physical training (i.e., unit fitness training, operational training, or recreational sports conditioning).

For further classification, overuse injuries were defined as musculoskeletal injuries presumably resulting from repetitive microtrauma associated with activities such as running, calisthenics, strength training, and marching. This category included injuries such as tendonitis, patellar femoral syndrome, and bony stress injuries. Traumatic injuries were specified as injuries associated with acute traumatic events. This category included injuries such as: sprains, strains, fractures, abrasions and lacerations resulting from a single event.

(e.g., falling from an obstacle on the confidence course, or twisting an ankle in a pothole). A limited duty injury was a musculoskeletal or dermatological complaint that resulted in a period of medically restricted activity prescribed by a physical therapist or physician for 24 hrs or more.

**Table 1. Physical training program during SWAB training**

	<b>Cardio-respiratory training</b>	<b>Muscular strength and endurance training</b>	<b>Flexibility</b>	<b>Other activities</b>
<b>Frequency</b>	5 times/wk	2 times/wk	Warm-up and cool down before and after each exercise session. Dynamic stretching daily	4-5 times/wk
<b>Intensity</b>	60-90% HRR	8-12 RM	Slight discomfort but no pain	60-90% HRR
<b>Duration</b>	60 min or more	Less than 60 min	10-15 sec per stretch for warm-up and cool down. 30 sec per stretch for improvement of flexibility	Up to 60 min
<b>Activities</b>	Running, marching with backpack on campus.  Sprint intervals of 100 and 220 yards, 3 times/wk, 4-10 reps each  Bike interval training of 30 and 60 seconds, 2 times/wk, 4-10 reps  Sled pulls of 15 seconds, 2 times/wk, 4-10 reps	Free weights  Resistance machines  Sit-ups  Pull ups  Push ups  Body weight squats  Core planks Sea turtles  Medicine ball whole body exercises	Static Passive, PNF  Dynamic Stretches: Knee hug Quad Stretch Butt kickers Spider man stretch Inch worms Shoulder 90/90 stretch Lateral lunge Stretch Hip flexor/quad stretch 2 inch runs Ankle band/monster walks/lateral squat	Recreation: all sports (duty and off duty)

## **2.4 Risk Factor Data**

Data on age, gender, and ethnicity were obtained from the Coast Guard Academy Data Tracking Computer System (ACADIS) at the beginning of each year. During the pre and post SWAB PFA, the cadet battalion trainer measured body weight and height. Height was measured to the nearest centimeter using a stadiometer. Weight was measured to the nearest 0.1kg using a SECA platform scale (Chino, CA). Body mass index (BMI) was calculated by dividing the subject's weight by the height squared ( $\text{kg}/\text{m}^2$ ) [6]. The initial (first) PFA data (sit-ups and 1.5 mile run) were also considered in the risk factor analyses.

Functional Movement Screening (FMS) is a testing procedure that examines the "quality" of movement patterns to presumably identify individuals that have specific limitations or asymmetries. Movement quality is identified by having individuals perform movements in highly specific ways. It is presumed that individuals who can more effectively control their body to accomplish the required movement pattern have a lower injury risk. FMS involves 7 movement tests and each test is scored on an ordinal scale with 4 levels (0 to 3) [7,8]. These scores are added together for a final score that can vary from 0 and 21. FMS tests were administered in a single session prior to SWAB training in accordance with FMS criteria [8]. The testing was conducted by research staff members including a physical therapist certified in FMS testing who monitored all testing. Each tester was trained on only the test they were administering. Cadets had a scoring sheet which they carried to all 7 tests. Cadets performed the tests in t-shirt, shorts, socks, and sneakers. Testing was conducted throughout the day as part of the cadet training schedule.

## **2.5 Statistics**

Statistical Package for the Social Sciences (SPSS, Version 18, Chicago, IL) was used for the statistical analyses. For descriptive purposes, means and standard deviations were calculated for continuous variables. Cumulative injury incidence was calculated as the number of cadets experiencing one or more injuries divided by the total number of cadets. Injuries were subcategorized into overuse and traumatic types, as defined above. The incidence of specific types of injuries and their anatomical location was determined.

To determine gender differences in PFA performance and changes in performance during SWAB training, a 2X2 mixed model analysis of variance (ANOVA) was used (gender X pre-post SWAB training). Gender was an independent factor and pre-post PFA was a repeated measures factor. An independent sample t-test was used to determine gender differences in performance on the 7 FMS tests.

To determine the association between injuries and potential risk factors, logistic regression was performed. Continuous variables (age, height, weight, BMI, FMS score, sit-ups and run times) were divided into four approximately equal groups. Variables found to be significantly associated with injury in univariate analyses were included in a backward stepping multivariate logistic regression. In the multivariate logistic regression, a low criterion was set for selecting variables from the univariate analysis ( $p < 0.10$ ) to allowing more variables into the analysis and to assure that none were missed that might have been important or that might have important interactions. After these variables were selected, the criterion for retention in the model was set at a less conservative and more conventional level ( $p < 0.05$ ). To obtain ORs and 95% CIs, each level of a risk factor was compared to a referent level.

### 3. RESULTS

Some of the data was not collected on some cadets, primarily because of scheduling conflicts so samples sizes are shown.

#### 3.1 Descriptive Data

Table 2 shows the descriptive data for age, physical characteristics, and physical fitness of the cadets in the study. Women were younger but only by 0.2 years. Women were also shorter, weighed less, had lower BMI, performed fewer sit-ups and ran slower compared to the men.

**Table 2. Age, physical measurements, and physical fitness of male and female USCGA freshmen cadets**

Measure	Men			Women		
	N	Mean	SD	N	Mean	SD
Age (yrs)	778	18.1	0.7	286	17.9	0.7
Height (m)	743	1.79	0.07	269	1.65	0.16
Weight (kg)	743	76.8	10.8	269	62.6	10.7
BMI (kg/m <sup>2</sup> )	741	23.6	3.2	269	22.7	2.7
Sit-Ups (n)	587	76	17	201	74	18
1.5-Mile Run (sec)	587	618	74	201	757	103

Table 3 shows the data from pre-(start of SWAB training) and post-PFA (end of SWAB training). Data were obtained from only about half of the men and women because of the difficulty in obtaining PFA data from the training units. For the run, men were faster than the women and both men and women improved during SWAB training. There was a significant interaction in the AVOVA indicating that the women improved more than the men. For SUs, there was no significant gender difference and both men and women improved during SWAB training. There was no significant ANOVA interaction for sit-ups indicating that both men and women improved a similar amount.

**Table 3. 1.5-mile run and sit-up performance of male and female uscga freshman cadets before and after SWAB training**

Event	Gender	N	Pre Mean±SD (sec or reps)	Post Mean±SD (sec or reps)	Δ (sec or reps)	Δ (%)	2X2 ANOVA p-values		
							Gender	Pre-Post	Interaction
Run	Men	379	611±67	583±62	-28	-4.6	0.12	<0.01	<0.01
	Women	135	753±86	686±63	-67	-8.9			
Sit-Ups	Men	379	77±17	88±13	+11	+14.3	0.12	<0.01	0.68
	Women	135	74±18	86±15	+12	+16.2			

Table 4 shows the FMS scores. Average scores were similar for men and women on most of the tests with two exceptions. Women had higher FMS scores on the assisted straight leg raise while men demonstrated significantly higher trunk stability push-up scores. The average total FMS score was identical for the men and the women with more variability (SD) among the women.

**Table 4. Functional Movement Screening (FMS) Test Scores of Male and Female USCGA Freshmen Cadets**

Test	Men			Women			p-value
	N	Mean (pts)	SD (pts)	N	Mean (pts)	SD (pts)	
Deep squat score	770	1.9	0.7	275	1.8	0.8	0.29
Hurdle step score	770	1.9	0.7	275	1.8	0.8	0.45
Inline lunge score	770	1.9	0.9	275	2.0	0.9	0.49
Shoulder mobility score	770	2.2	0.9	275	2.2	1.0	0.67
Assisted straight leg raise score	770	1.9	0.8	275	2.2	0.9	<0.01
Trunk stability push-up score	770	2.2	1.1	275	1.8	0.7	<0.01
Rotary stability score	769	1.8	0.5	275	1.8	0.6	0.96
Total functional movement score	769	13.1	4.7	275	13.1	5.4	0.96

### 3.2 Injury Data: Clinic Records

Medical records were obtained on the entire sample of 778 men and 286 women. There were 3 men and one woman who left the academy before the end of SWAB training because of academic issues. During the 4-year period, 18.4% (143/778) of the male cadets experienced one or more injuries attributed to training for which they made 157 clinic visits. Of female cadets, 23.8% (68/286) incurred one or more training-related injuries for which they made 73 clinic visits. Thus, the OR (women/men) was 1.39 (95% confidence interval=1.00 to 1.92).

Table 5 presents the diagnoses and anatomical locations of the injuries and makes comparisons between genders. Women had a higher proportion of overuse soft tissue injuries and men tended to have more abrasions/lacerations. With regard to anatomical location, women had over 3 times the risk of a shin/calf injury while men had over 6 times the risk of a thigh injury.

Table 6 shows the LDD by diagnosis and anatomical location. For the men, tears/ruptures and bone stress injury were associated with the greatest number of LDD per injury. The head and neck were the anatomical locations associated with the greatest LDD per injury. For the women, bone stress injuries were associated with the greatest number of LDD per injury, although there was only one of these. The low back was the anatomical location associated with the greatest number of LDD per injury. The number of LDD associated with overuse soft tissue injuries was higher among the women compared to the men. The number of LDD resulting from the ankle and thigh injuries was higher among the men compared to the women. The number of LDD resulting from the shin/calf injuries was higher among the women compared to the men.

### 3.3 Risk Factor Data

In the univariate logistic regression analyses, no significant relationships were observed between injuries and age, ethnicity, height, or weight. Table 7 shows the results of the multivariate logistic regression. Independent injury risk factors for both men and women included lower aerobic fitness and lower FMS total scores. Although BMI was significant in univariate analysis it was not when included in the multivariate analysis with run times and FMS scores.

**Table 5. Injury Diagnoses and Anatomical Locations Associated with SWAB Training in USGA Male and Female Freshmen Cadets**

	Men (N = 778)		Women (N = 286)		Comparison	
	Yes n (%)	No n (%)	Yes n (%)	No n (%)	OR (95 % CI)	P-values
<b>Diagnosis</b>	108 (13.9)	670 (86.1)	62 (21.7)	224 (78.3)	1.72(1.21 -2.43)	<0.01
Overuse soft tissue <sup>a</sup>						
Bone stress injury <sup>b</sup>	3 (0.4)	775 (99.6)	1 (0.4)	285 (99.6)	1.103(0.11–10.65)	0.93
Fracture	0 (0.0)	778(100.0)	0 (0.0)	286 (100.0)		---
Dislocation/sublux	9 (1.2)	769 (98.8)	2 (0.7)	284 (99.3)	1.66 (0.36 - 7.74)	0.75
Strains/sprains	5 (0.6)	773 (99.4)	2 (0.7)	284 (99.3)	1.01 (0.21- 5.64)	0.74
Abrasions/contusions	11(1.4)	767 (98.6)	0 (0.0)	286 (100.0)	8.19 (0.48-139.8) <sup>d</sup>	0.16
NOS traumatic <sup>c</sup>	58 (7.5)	720 (95.5)	24 (8.4)	262 (91.6)	0.14 (0.69- 1.87)	0.70
<b>Anatomical Location</b>						
Knee	46 (6.0)	732 (94.1)	15 (5.2)	271 (94.8)	1.13 (0.64 - 1.99)	0.68
Ankle	22 (2.8)	756 (97.2)	20 (7.0)	266 (93.0)	2.58 (1.39 – 4.81)	0.08
Shoulder	19 (2.4)	759 (97.6)	7 (2.4)	279 (97.6)	1.0 (0.42 - 2.35)	0.10
Shin/calf	17 (2.2)	761 (97.8)	18 (6.3)	268 (93.7)	3.01 (1.53 – 5.92)	<0.01
Thigh	18 (2.3)	760 (97.7)	1 (0.3)	285 (99.7)	6.75 (0.90 - 50.8)	0.03
Arm/wrist/hand	13 (1.7)	765 (98.3)	6 (2.1)	380 (97.9)	1.07 (0.41 - 2.81)	0.88
Foot	12 (1.5)	766 (98.5)	9 (3.1)	277 (96.9)	2.07 (0.86 – 4.98)	0.10
Hip	7 (0.9)	771 (99.1)	3 (1.0)	283 (99.0)	1.17 (0.30 – 4.56)	0.82
Head/neck	1 (0.1)	777 (99.9)	2 (0.7)	284 (99.3)	5.47(0.39– 152.86)	0.12
Low back	2 (0.3)	776 (99.7)	3 (1.0)	283 (99.0)	4.11(0.68 – 24.74)	0.09
Upper back	2 (0.3)	776 (99.7)	0(0.0)	286 (100.0)	1.48 (0.06- 32.82) <sup>d</sup>	0.63
Trunk	1 (0.1)	777 (99.9)	1 (0.3)	285 (99.7)	2.73 (0.17 – 43.73)	0.47
Not specified <sup>f</sup>	34 (5.8)	744(96.0)	6 (0.1)	280(97.9)	2.13 (0.92-5.63)	0.08

<sup>d</sup>Odds ratios were estimated by putting 0.5 into the zero cell<sup>27</sup><sup>f</sup>Anatomical location not specified on the medical records<sup>c</sup>NOS traumatic = not otherwise specified traumatic injuries



**Table 6. Injuries and Limited Duty Days Associated with SWAB Training in USGA Male and Female Freshmen Cadets**

	Men (N = 778)			Women (N = 286)			ANOVAS Comparing LDD (p values)
	Injured No.	Total LDD <sup>a</sup>	Mean <sup>b</sup> +SD	Injured No.	Total LDD <sup>a</sup>	Mean <sup>b</sup> +SD	
	108	26	0.4±1.2	62	33	0.5±2.0	0.01
<b>Diagnosis</b>							
Overuse soft tissue <sup>c</sup>							
Dislocation/sublux	9	18	1.6±4.2	2	4	2.0±3.0	0.47
Tears/ruptures	7	62	8.9±14.5	2	0	1.0±1.4	0.92
Abrasions/contusions	11	10	0.7±1.1	0	0	0.0±0.0	†
NOS traumatic <sup>e</sup>	58	106	1.6±5.1	24	40	1.7±4.0	0.12
<b>Anatomical Location</b>							
Knee	46	66	1.4±6.2	15	20	1.3±3.7	0.95
Ankle	22	10	0.5±0.9	20	4	0.5±1.2	0.99
Shoulder	19	36	1.9±3.8	7	6	0.4±0.8	0.91
Shin/calf	17	1	0.1±0.2	18	6	0.3±1.2	0.33
Thigh	18	11	0.6±1.1	1	0	0.0±0.0	†
Arm/wrist/hand	13	3	0.2±0.8	6	10	1.7±1.2	0.36
Foot	12	19	0.4±2.8	9	0	0.0±0.0	†
Hip	7	0	0.0±0.0	4	2	0.7±1.2	0.13
Head/neck	1	14	14.0±0.0	2	0	0.0±0.0	†
Low back	2	0	0.0±0.0	3	16	5.3±7.3	0.50
Upper back	2	3	1.5±2.1	0	0	0.0±0.0	†
Trunk	1	0	0.0±0.0	1	1	1.0±0.0	†
Not specified <sup>e</sup>	34	131	3.9±2.0	6	29	4.8±5.0	0.00

<sup>a</sup> LDD = Limited Duty Days<sup>b</sup> Mean= average number of limited duty days per injured soldier<sup>c</sup> Overuse soft tissue = fasciitis, tendonitis, strains/ sprains<sup>d</sup> NOS traumatic = not otherwise specified traumatic injuries<sup>e</sup> Anatomical location not specified on the medical records<sup>f</sup> Not computed because of zero cell

**Table 7. Multivariate logistic regression results**

	Variable	Variable Ranges	N	Odds Ratios (95% Confidence Interval)	p-value
Men	Run Times (s)	460-572	144	1.00	Referent
		573-614	136	1.35 (0.74-2.47)	0.33
		615-659	145	1.47 (0.81-2.67)	0.20
		660-1040	150	2.17 (1.20-3.92)	<0.01
Women		539-703	49	1.00	Referent
		704-751	47	1.90(0.68-5.31)	0.22
		752- 822	48	3.46(1.26-9.51)	0.02
		823-1074	48	4.08(1.48-11.22)	0.01
Men	FMS Score (0-21)	0-12	119	2.12 (1.01-4.47)	0.05
		13-14	173	1.64 (0.80-3.36)	0.18
		15-16	206	1.76 (0.87-3.55)	0.11
		17-20	77	1.00	Referent
Women		0-12	42	2.18 (1.14-4.17)	0.03
		13-14	44	1.97 (1.03-3.77)	0.04
		15-17	66	1.46 (0.56-3.79)	0.50
		18-19	40	1.00	Referent
Men	BMI (kg*m-2)	16.0-21.3	121	1.26 (0.73-2.17)	0.41
		21.4-23.1	142	0.66 (0.36-1.18)	0.16
		23.2-25.3	150	1.00	Referent
		25.4-35.0	162	0.87 (0.52-1.48)	0.61
Women		14.7- 20.7	53	0.89 (0.37-2.19)	0.81
		20.8 -22.2	45	0.38 (0.14-1.03)	0.06
		22.3-24.3	43	1.00	Referent
		24.4-30.8	51	0.61 (0.26-1.43)	0.25

#### 4. DISCUSSION

This study was the first to quantify the injury risk in Coast Guard cadet SWAB training and to examine potential risk factors for these injuries. The investigation demonstrated that 18% of male and 24% of female cadets incurred one or more physical-training related injuries, during 4 cycles of the 8-week SWAB training. The incidence of overuse injuries and the number of LDDs for overuse injuries were higher among the women, while the incidence of traumatic injuries was similar for men and women. A majority of injuries (79%) involved the lower extremities with the shoulder the most common upper body location. Risk factors for injuries included lower aerobic fitness and lower FMS scores.

The incidence of injured male and female cadets in this study was lower when compared with epidemiological studies on Army cadets at the US Military Academy (USMA) at West Point, New York [9]. Here, 28% men and 61% of women undergoing cadet basic training were injured. The training program at that location included running, calisthenics, marching, and traversing obstacle courses, similar to that of the Coast Guard cadets [9].

In consonance with the present investigation, previous military basic training investigations have reported that 77% to 88% of injuries are experienced in the lower body/lower back, with the knees, ankle, and foot among the most common anatomical locations [4-10]. Also, in

consonance with the present study, overuse soft tissue injuries like sprains, strains and abrasions/lacerations appear to be among the most common types of diagnoses in basic training [10,11] as well as in athletic training [12-15].

Compared to the men, women had a greater proportion of overuse injuries. These types of injuries also incurred a greater number of LDDs among the women. Other studies have also found that when physical activity is similar, women appear to be more susceptible to overuse type injuries[16-18]. There also tended to be a larger proportion of low back injuries among the women. Back injuries can require frequent clinic visits and rehabilitation [3,16].

In the present study, physical activities performed by the cadets like running, marching with packs, calisthenics, and navigating through the obstacle course could lead to overuse strains and sprains and soft tissue injuries of low back and lower extremities [9,10]. It is important to note that the females on average had slower run times and sit-up scores than the males on the initial PFA. Low physical fitness has been implicated as a risk factor for overuse type injuries in other military studies, [4,16] as well as in the present investigation.

In the present study, both men and women improved their fitness during SWAB training, although the improvement on the run was greater for the women than for the men. Previous studies in Air Force basic training showed a similar result, with men improving their performance 9% while women improved about 14% [19]. On the other hand, in the Air Force investigation women also improved more than the men on a “crunch” test (similar to sit-ups), a finding different from the present one. In the Air Force study the women began training at a lower “crunch” performance level compared to the men, but reached a similar final performance level, as in the present study. The fact that the physical training program was virtually identical for men and women in the Air Force study and the present study likely accounts for the differences in the abdominal testing results. Physical training programs that are similar for men and women will “challenge” women to a greater extent than the men if the women have a lower initial fitness level. This will result in greater fitness improvements among the women. However, when initial fitness levels are the same for men and women, and the physical training program is similar, improvements will likely be similar [19].

Significant risk factors for injuries among both men and women included lower aerobic fitness and lower FMS scores. Other military studies have shown that lower aerobic fitness increases injury risk [4,5,10]. Lower aerobic fitness will result in higher relative exercise intensity (i.e., higher %VO<sub>2</sub>max) because training intensity is virtually identical for all cadets. Lower aerobic fitness will be associated with more rapid fatigue and alternate movement patterns (as active muscle groups fatigue) leading to higher injury risk [4]. A few studies have investigated the use of the FMS as a predictor of injury in athletic populations [2,20,21,22]. These studies show an increase in injury with FMS scores lower than 14 which is similar to this study’s findings. The FMS was developed to identify unstable neuromuscular movement patterns that may reinforce poor biomechanics during occupational and athletic tasks [23]. It seems possible that a lower ability to control movement may increase injury risk.

## **5. STUDY LIMITATIONS**

Our research study had limitations. Limited duty data were not always recorded in the troop medical records so time lost from training was likely underestimated. These data are important for determining the degree of severity of injuries and the potential monetary impact of time lost from SWAB training at the USCGA.

We obtained medical data from physical therapy and troop medical clinic records. Even though the study staff attempted to determine a specific injury diagnosis for each visit, some of the injuries in the troop medical records did not list an anatomical location.

Also missing from the medical records were the activities associated with injuries. Identifying activities associated with injuries is one of the early steps in the injury prevention process. Once these activities have been identified they can be targeted for interventions that might reduce injury incidence [24]. Without knowledge of the causes of injuries it is difficult to know how to prevent them or to set priorities for prevention.

Finally, it has been suggested in other military studies that gender differences in musculoskeletal injury incidence may be due to reporting differences between female and male recruits. Female recruits may be more likely to report injuries than male recruits [25].

## **6. CONCLUSION**

The current study revealed that the incidence of injuries was higher among women compared to men in SWAB training. This was especially apparent for overuse injuries. Both male and females cadets were more likely to incur an injury if they entered the training program with lower aerobic fitness and lower FMS scores. Further investigations are necessary to design preventive strategies to reduce injuries in this military population.

Previous studies have shown that improving fitness reduces injuries in BCT so a pre-SWAB training program designed to improve fitness is likely to reduce injuries [26]. Future studies should be directed at determining the injury reduction efficacy of modifying inefficient movement strategies (FMS scores).

## **CONSENT AND ETHICAL APPROVAL**

All authors declare that Institutional approval for human subjects' experimentation was given by the USCGA for this project.

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## **COMPETING INTERESTS**

The authors declare that they have no competing interest.

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