Risk Factors for Sustaining a Lower Extremity Injury in an Army Reserve Officer Training Corps Cadet Population

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ABSTRACT Injuries acquired during Reserve Officer Training Corps (ROTC) participation can potentially affect a cadet's future and career in the armed forces. The purpose of this study was to identify risk factors associated with lower extremity injuries in an Army ROTC cadet population. There were 195 (165M, 30F) cadets enrolled in an Army ROTC program, 18 to 33 years old, with an average body mass index (BMI) of 23.5 ± 2.85. Injury data were retrospectively obtained from the electronic medical records maintained by a Certified Athletic Trainer. Descriptive statistics, frequencies, and incidence rate for physical training (PT) were calculated. Survival analysis determined association between injury and several variables (Military Science [MS] year, army physical fitness test scores, BMI, sex, previous lower extremity injury, PT exposures, most frequent boot worn, current and prior physical activity, and collision sport participation). Kaplan–Meier curves were used for the categorical variables. Incidence rate was 60 lower extremity injuries/100 person-years during PT. The survival analysis revealed MS year ($p < 0.001$) and PT exposures ($p < 0.001$) were significant in predicting risk of injury. All other variables were not significant. On the basis of this preliminary data, footwear and activity have no implications on risk of lower extremity injury. Preventative measures should be focused toward younger cadets because of their increased risk for injury.

INTRODUCTION

The Army Reserve Officer Training Corps (ROTC) is the largest commissioning source in the American military. ROTC provides leadership and military training at schools and universities across the country with a total enrollment of over 20,000 cadets.[1] Army ROTC currently produces approximately 60% of all the Second Lieutenants who join the Army, Army Reserve, and Army National Guard. More than 40% of current Active Duty Army General Officers were commissioned through ROTC.[1]

Physical strength and endurance are greatly emphasized in military training.[2–4] Because of the intensity of physical training (PT), the incidence of training-related injuries is high across military populations.[3,5] Although injuries occur across a wide range of body parts, the majority of injuries that occur in the military population occur in the lower extremity.[2–5] These injuries account for approximately 37% to 85% of all injuries.[2–8] An array of risk factors may contribute to the high rate on injuries in the military including year in ROTC, current body mass index (BMI), past history of lower extremity injury, PT exposures, current physical activity outside of ROTC, previous physical activity, military specific footwear, and type of military activity. Anecdotally, it is suggested that a contributory cause of injury could be found in the nature of organized service activities. These activities include PT, marching, and field training.[2] Marching and field training account for the vast majority of activity during basic training,[1,9] while PT (exercises that focus on running, calisthenics, stability training, conditioning, military movement, and stretching) accounts for the majority of activity time in ROTC. Marching and field training account for less than 35% of activity time in ROTC. Even in a normal physically active population, it is understood that increased activity exposures lead to an increased risk of injury. However, in this population, additional constraints may be placed on the cadet. For example, during marching and field training, recruits wear standard military footwear and clothing, including the standard issue military boot (leather upper and rubber sole), and are often carrying additional loads.[1,2,9] Currently, it is unclear how these additional constraints impact recruits' risk of injury.

Because of the nature of military activity, the military boot is designed to accommodate the wide variety of tasks completed by military personnel.[9–11] In comparison to commercial footwear (i.e., running shoes), standard issue military boots have a low energy return, higher weight, and are less flexible in the upper as well as the sole.[11–13] Although the military boot is durable, stabilizes the ankle, and offers protection from direct trauma, it lacks the shock-absorbing qualities and flexibility of the running shoe.[14] These factors can accelerate energy loss and lead to the onset of muscle fatigue and additional stress on the plantar aspects of the foot.[11–13] It has also been suggested that military boots have lower shock attenuation compared to commercial footwear, which is an important biomechanical risk factor for musculoskeletal injury.[9,11,15–17] In addition, not all types of military boots are the same (i.e., combat boot and jungle boot). Therefore, based upon the type of boot, injury outcomes may differ as well.[18] Marching in particular is regarded as the cause of most injuries, mainly overuse injuries to the lower limbs.[19]

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doi: 10.7205/MILMED-D-14-00618

The vast majority of research concerning injury in a military population has been done in the U.S. Army basic training population. To date, there has been no research investigating injury incidence in an ROTC population. It is incredibly important to recognize that a cadet's ROTC experience and physical performance scores influence their placement and further performance after commissioning. An injury that goes unrecognized and untreated can cause complications not only during ROTC training but also in the commissioning process and routine training. This can all occur before a cadet attends basic training or officer's candidate school. Therefore, the primary purpose of this study was to identify risk factors associated with lower extremity injuries in an ROTC population.

METHODS

Data were collected on all cadets enrolled in a large university Army ROTC program from August 1, 2012 to December 20, 2013. This cohort study collected data retrospectively. The data collected were potential risk factors associated with lower extremity injury and the outcome of interest was lower extremity injury.

Study Population

Participants consisted of 195 cadets that were in Army ROTC between August 1, 2012 and December 20, 2013. This included 165 male and 30 female cadets 18 to 33 years old, with an average BMI of 23.5 ± 2.85 kg/m^2. There were 53 Military Science (MS) I's (i.e., in the first year of training), 55 MSII's, 49 MSIII's, and 38 MSIV's. Since the MS year refers to a cadet's year in the ROTC program, MSI's are predominately freshman, MSII's are sophomores, etc. The only criterion for exclusion was any cadet who was under the age of 18 at the time of injury. However, no cadets were under the age of 18 at the time of injury so no one was excluded. Participants were identified from attendance rosters maintained by ROTC staff. The study was approved by the University's Institutional Review Board for the Protection of Human Subjects. A waiver of written informed consent was obtained.

Injury Data Collection

Injury data were collected on all patients seen by the Certified Athletic Trainer (ATC), all were direct access, (i.e., were not referred into the study). Any lower extremity musculoskeletal injury acquired by a cadet was recorded. Only the first injury event per cadet was included in injury data. No repeat injuries were included. Any injury occurring bilaterally was considered a single injury event. All evaluations occurred at the Athletic Training Laboratory or at the sanctioned activity site. Once a cadet reported an injury to the ATC, an injury evaluation was completed and recorded. Once a month, injury data were obtained from the electronic medical records (SportsWare 2011 v14.01, CSMI Medical Solutions, Stoughton, Massachusetts), which was maintained by the Athletic Trainer. Data that were collected retrospectively from the injury database included body region injured (hip, thigh, knee, lower leg, ankle, or foot) and diagnosis (sprain, strain, fracture, and other). Additional variables collected at the time of injury included MS year, age, footwear type (government issued boot, government-approved boot, and conventional running shoe), activity type (PT, field experience, and nonsanctioned activity), injury mechanism, and time to injury. Periods when ROTC was not in session (i.e., summer, winter break, and spring break) were excluded from the total days.

Medical Physical Data Collection

In addition, data were obtained from medical physical examination records. All Army ROTC cadets are required by the program to obtain medical physicals. Cadets obtained physicals from their primary care physician or a military physician. Demographic data including participant sex, height, weight, and previous lower extremity injury were collected from all medical physicals. The medical records are legal, chronological documents that contain the history of medical care for all cadets. BMI was calculated using the formula weight (kg)/[height (m)]^2 for each cadet.

Army physical fitness test (APFT) scores were collected from records maintained by the Army ROTC staff. The APFT is designed to test muscular strength, endurance, and cardiovascular fitness. The ROTC cadets participate in three events consisting of push-ups, sit-ups, and a two-mile run.[19] Cadets receive a score from 0 to 100 points in each event. A minimum score of 60 in each event is required to pass the test.[19] Scoring is based on sex, age category, and number of repetitions performed or run time.[19] Score tables are found on the Department of the Army form 705.

PT exposures were collected from the attendance records provided. PT exposures were counted as each singular time a cadet attended PT throughout the study. PT sessions were conducted on a regular basis (3 times per week) and included standardized PT(warm-up, activity, and cool-down), and various exercises that focused on running, calisthenics, stability training, conditioning, military movement, and stretching.

Footwear and Activity Survey

Additional data regarding footwear as well as previous and current physical activity were collected via survey. Data collected included most frequent boot type worn, current organized physical activity participation, prior organized physical activity participation, and prior collision sport participation.

Statistical Analysis

Descriptive statistics and frequencies have been provided for all variables. Incidence rates were calculated for PT only, the denominator in person-years (PY), based upon the total number of PT exposures. Survival analysis was performed

TABLE I. Means and Standard Deviations for Army ROTC Cadet Characteristics (N = 195)

	Minimum	Maximum	Mean	*N*
Age (Years)	18.0	33.0	20.5 ± 2.17	195
BMI Classification (kg/m^2)				
Underweight-Normal (≤24.9)	17.2	24.9	22.2 ± 1.76	141
Overweight-Obese (≥25.0)	25.1	36.5	27.0 ± 2.15	54
APFT Scores (Points)	36.0	300.0	229.8 ± 49.16	194
PT Exposures (Count)	0.0	103.0	49.6 ± 28.37	195

to determine how several independent variables (MS year, APFT scores, BMI, sex, previous lower extremity injury, PT exposures, most frequent boot worn, current and prior physical activity, and history of participating in a collision sport) are associated with the rate of lower extremity injury. The categories for PT exposures were dichotomized using a cut-off of ≤50 and >50 as 50 was the median number of PT exposures. BMI categories were based on the standardized BMI categories (Underweight [below 18.5], Normal [18.5–24.9], Overweight [25.0–29.9], and Obese [30 and above]); however, categories were then dichotomized as Underweight/Normal and Overweight/Obese.

The predictor variables were explored first using univariate analyses. Kaplan–Meier curves using log-rank test of equality across the strata (nonparametric) was used for the categorical variables. Potential predictor variables had to have a p value ≤0.2 to be included in the regression model. After determining which predictors might be associated with risk of injury based univariate analyses, a model was built using PROC PHREG. The full model included all predictors from univariate analyses meeting the criterion described above as well as any variables necessary for answering the study aims. The PHREG procedure performed regression analysis of survival data based on the Cox proportional hazards model. Reduction in risk of sustaining a lower extremity injury was calculated (1-hazard ratio) from the hazard ratios to interpret the MS Year variable. Statistical analysis was performed using the SAS system, version 9.3 (SAS Institute, Cary, North Carolina).

TABLE II. Frequencies of Army ROTC Cadet Characteristics by Censored Status

	Injured *N* (%)	Noninjured *N* (%)
Sex		
Male	32 (19.4)	133 (80.6)
Female	9 (30.0)	21 (70.0)
MS Year		
MS I	15 (28.3)	38 (71.7)
MS II	11 (20.0)	44 (80.0)
MS III	10 (20.4)	39 (79.6)
MS IV	5 (13.2)	33 (86.8)
BMI Classification		
≥24.9	35 (24.8)	106 (75.2)
≤25.0	6 (11.1)	48 (88.1)
APFT		
Pass	30 (21.1)	112 (78.9)
Fail	11 (21.2)	41 (78.8)
History of LE Injury		
Yes	7 (35.0)	13 (65.0)
No	34 (19.4)	141 (80.6)

RESULTS

Means and standard deviations for characteristics of Army ROTC cadet participants are reported in Table I. Frequencies for cadet characteristics by injury status are reported in Table II. Descriptive statistics revealed that of the 195 subjects, 41 (21%) sustained a lower extremity injury during their time of enrollment in the study. Of the individuals that sustained a lower extremity injury, the average time to injury was 120.15 ± 85.69 days. Incidence rate was estimated to be 60 lower extremity injuries/100 PY spent engaged in PT. Frequencies for characteristics of the 41 injuries including location, diagnosis, ROTC activity, and footwear at the time on injury are reported in Table III.

Survival Analysis

Univariate Analyses

The log-rank test of equality across strata for MS Year revealed a p value of <0.0001, thus MS Year was included as a potential candidate for the final model. In addition to

TABLE III. Injury Characteristic Frequencies

	N (%)
Location	
Hip	2 (4.9)
Thigh	5 (12.2)
Knee	8 (19.5)
Lower Leg	9 (22.0)
Ankle	12 (29.3)
Foot	5 (12.2)
Diagnosis	
Sprain	13 (31.7)
Strain	15 (36.6)
Fracture	1 (2.4)
Other	12 (29.3)
Footwear	
Government Issued	7 (17.1)
Conventional Running Shoe	17 (41.5)
Other	17 (41.5)
Activity	
Physical Training	16 (39.0)
Field Training	5 (12.2)
Non-ROTC	20 (48.8)

TABLE IV. Univariate Test of Equality Over Strata

Risk Factor	χ^2 (Log Rank)	*p* Value
MS Year	21.28	<0.0001
APFT Score	0.24	0.62
BMI	4.06	0.04
Sex	2.98	0.08
Previous History of LE Injury	2.63	0.10
PT Exposures	1.35	0.25
Boot Type	0.19	0.91
Current Physical Activity	0.75	0.69
Previous Physical Activity	0.19	0.91
Collision Sport Participation	0.06	0.81

MS Year, BMI classification ($p = 0.04$), sex ($p = 0.08$), past history of lower extremity injury ($p = 0.10$), and PT exposures ($p = 0.25$) were all included as potential candidates for the final model. Because there is evidence that injury risk increases with increased physical activity exposures, the predictor PT exposures were included despite having a p value above 0.2. There was no significance found for most frequent boot type worn (government issued, government approved, and both equally) ($p = 0.90$), current activity (Indiana University Recreational Sports, Other, None) ($p = 0.68$), previous activity (High School Athletics, Other, None) ($p = 0.91$), and collision sport participation (Yes and No) ($p = 0.81$). Therefore, these variables were not included as candidates for the final model. Frequencies and Log-rank test of equality over strata values for each variable included in the full model are reported in Table IV.

Modeling

The predictors sex ($p = 0.80$), BMI classification ($p = 0.06$), and previous history of lower extremity injury ($p = 0.28$) were not significant (Table V). The predictors PT exposures ($p < 0.0001$) (Fig. 1) and MS Year ($p < 0.0001$) (Fig. 2) were both significant. The hazard ratio reveals a relative risk of 49.1% for PT exposure, meaning that if a cadet has 50 or more PT exposures, they are 49.1% more likely to sustain a lower extremity injury. For MS year, hazard ratios provided for years 2, 3, and 4 are in comparison to year 1 and reduction in risk were calculated. Therefore, an MS 2, 3, and 4 had a decrease in risk of sustaining a lower extremity injury (71%, 76%, and 77%, respectively) relative to MSI's. The tests of all the time-dependent variables were not significant individually or collectively. With this information the assumption of proportionality for this model was satisfied.

TABLE V. Analysis of Maximum Likelihood Estimates—Full Model

Parameter	χ^2	*p* Value	Hazard Ratio
BMI Classification	3.35	0.06	0.74
Sex	0.06	0.81	1.05
Past History of LE Injury	1.14	0.28	0.77
PT Exposures	15.54	<0.001	0.51
MS Year II	25.27	<0.001	0.29
MS Year III	34.19	<0.001	0.24
MS Year IV	31.54	<0.001	0.23

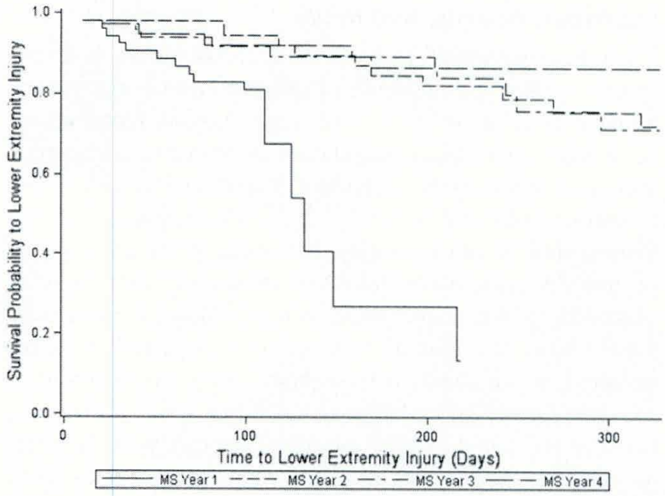

FIGURE 1. Survival curves of time to lower extremity injury by military science year.

DISCUSSION

Results from our study revealed that MS year and PT exposures are associated with an increased risk of lower extremity injury in an Army ROTC cadet population. Specifically, as an MSI, and with a higher amount of PT exposures, a cadet has a higher chance of sustaining an injury. In addition, it was revealed that the type of boot wear (government issued boot, government-approved boot, and both equally) and both past activity (high school sports, other, and none) as well as current activity (IU recreational sports, other, and none) have no measureable implications on risk of lower extremity injury in this study population.

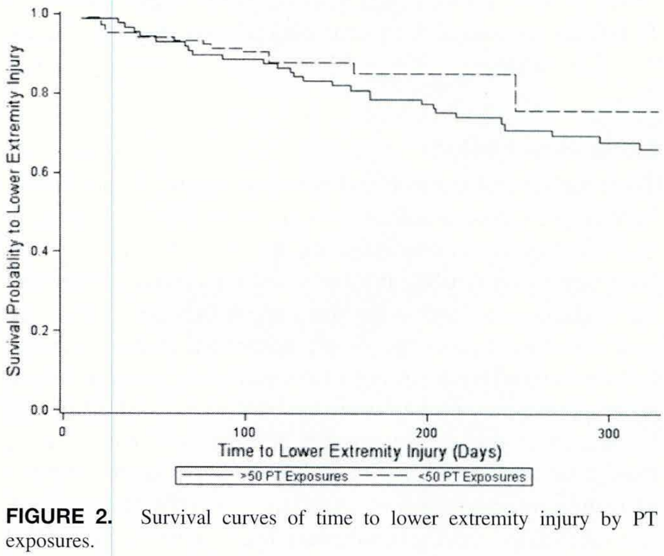

FIGURE 2. Survival curves of time to lower extremity injury by PT exposures.

Footwear, Activity, and Injury

It has been suggested that the standard issue boot is a contributor to the high incidence of overuse injuries in a general military population.[15,16,20] The suggestion is that military boots have lower shock attenuation compared to commercial footwear, which is an important biomechanical risk factor for musculoskeletal injury.[9,11,15–17] We hypothesized that there would be more injuries that occur or are exacerbated by military issue boots; however, there were more injuries sustained in the conventional running shoe. It should be noted, however, that all injuries that occurred in boots occurred in the standard issue boot, and none occurred in any government-approved model. Despite these differences, Paisis et al[10] found that the use of the standard issue boot has no negative effect on walking and running kinematics when compared to commercial footwear. Additionally, in a study of Israeli infantry recruits, it was found that the incidence of overuse injuries did not differ between groups training in standard issue boots versus a basketball shoe despite the increased shock attenuation of the basketball shoe.[15,16] Our findings align with this literature as we did not find any association between footwear and injury.

The incidence rate of 60/100 PY lower extremity injuries years means that when 100 cadets are followed, 60 lower extremity injuries will occur at PT over the course of a 365 days of PT. Fewer injuries occurred at field training compared to PT (12% versus 39% respectively). There were a total of 14,515 exposures between PT and field training, with PT accounting for 67% of exposures, and field training accounting for 33% of exposures. PT is conducted three times per 7 days (1 week), field training is conducted once a week with a weekend-long field training exercise once per semester. This is also program specific and varies between ROTC programs across the country. In the current literature, it is only speculated that footwear and activity have an impact on sustaining an injury. On the basis of the literature, our data, and the unequal distributions of footwear and activity, we cannot conclude that footwear and activity, both in and outside of ROTC are associated with sustaining a lower extremity injury in this population.

Other Risk Factors

There are several intrinsic and extrinsic factors that are speculated to predispose a recruit to injury during military training. Intrinsic factors said to influence the risk of injury include bone density, age, BMI, prior physical condition, psychological makeup, sex, and other anatomical factors.[21] However, many of these factors are simply speculated to have a negative impact and have not been fully proven to increase risk of injury. There may be a relationship of BMI and risk of injury, but it is likely that the relationship between BMI and injury is likely J or U shaped rather than linear. This made the number of people in each category insufficient to allow for separate analyses based on the traditional four categories of BMI; because of this we had two categories for BMI. Our study investigated many of these factors, in addition to MS year, PT exposures, and APFT scores. It was revealed that a higher number (greater than 50) of PT exposures are a risk factor for an increase in lower extremity injury. This makes sense because the more times a cadet attends PT, they are likely to increase their chances of injury. PT exposures among all cadets ranged from 0 to 100, with an average of about 50. There is no class that specifically had a higher number of PT exposures.

Initially, we hypothesized that injuries would occur evenly across classes; however, we found that over time MSI's have a higher risk of sustaining a lower extremity injury. Besides PT, there is a great deal of variability in training between all of the classes. MSI's are simply "learning the ropes," but this also means that they are completing physical tasks on a somewhat daily basis that they may not have experience with. For cadets who do not have athletic experience, this will be the most difficult part of joining ROTC. MSII's are familiar with some of this military activity, but they are continuing to learn and improve their skills. MSIII's are at the height of their training. They are preparing all year for the Leader Development and Assessment Course, which determines the direction of their military career. Although their activity level increases, they generally have more experience from their previous years in the program or from experience with the National Guard. MSIV's do a lot of administrative work and planning, carrying out events for the rest of the cadets. They do very little tactical skill and exercise outside of PT. This is perhaps why MSIV's that have not previously sustained an injury are shown to have a very low risk of injury. It is possible that the increased risk for an MSI is a lack of experience in endurance training, training over uneven terrain, and a lack of experience in tactical training. In addition to these factors, MSI's are experiencing a drastic lifestyle change when they begin college.

One of the most highly reported risk factor for injury in the military is sex. The injury rate among female trainees have been reported at 1.5 to 2.0 times higher than those for their male counterparts.[3,4,8,18,22–24] Although we found a higher percentage of females were injured compared to males, we had a very unequal distribution of males and females (165 and 30, respectively). Therefore, we cannot come to the conclusion that more injuries occur over time, simply based upon sex. This also applies to several other variables we investigated. A much higher number of cadets fell under the underweight-normal BMI category compared to overweight-obese. Because we are working with a highly physically active population, BMI is likely to be normal. This skews the data to show that there are more injuries in the underweight-normal category. This is also apparent with APFT scores, where the majority of cadets passed their APFT, and a majority of cadets did not have a previous history of lower extremity injury. Although the literature heavily reports that these factors play a large role in risk for injury,[3,4,7,22,25] based on the unequal distribution of subjects in these categories, we are unable to make any conclusions that these factors are correlated to an increased risk of injury.

LIMITATIONS

This study was limited in that it is difficult to compare to the current literature as it was the first to be conducted with an ROTC population. Almost all of the current literature on injury in the military has been conducted with a basic training population, where subjects are conducting military activity such as PT, ruck marches, and tactics consistently on a day-to-day basis. In ROTC, military training accounts for a very small portion of a cadet's daily life, especially in the MSI and MSII years. In a basic training population, soldiers are constantly under supervision of cadre, whereas in ROTC, there is very little accountability for outside activity and behavior of cadets. Injuries in cadets often occur during these outside activities such as club/intramural sports, and activities of daily living. There is also something to be said for the stark contrast of active duty military life versus the lifestyle of a full-time college student. Other limitations include a limited training time in a military boot, a small sample size, the disproportion of sex represented in the sample. Boot type and previous activity data were also collected retrospectively, without a full representation of the sample.

CLINICAL IMPLICATIONS

Prevention of injury and identifying risk factors of injury is one of the most important things to consider concerning injury in the military. Because the military is such a physically demanding profession, when being considered for enrollment in an ROTC program, students should be fully educated on expectations of the program. Preconditioning of recruited students should be implemented to prime these students for the physical demands of the program.

When the cadets commission as Second Lieutenants, they will have to educate their soldiers on how to take care of their bodies, and how to stay physically fit. As clinicians, we need to set up these cadets with a good foundation of exercise and health care habits from the beginning of their enrollment in an ROTC program. On the basis of our data, if we can reduce MSI injuries, we can drastically reduce injury as they progress throughout the program.

FUTURE RESEARCH

There are still many factors that remain in speculation whether or not they contribute to injury in the military. Specifically, because this was the first study conducted in an ROTC population, it would be ideal for this study to be replicated, perhaps with a larger sample. Ideally, footwear and activity data would be collected prospectively with the initial data collection so that the entire sample is represented. Further research between types of military boots is especially warranted, as our study could only speculate that Government Issue boots exacerbate more injuries than government-approved models.

CONCLUSION

On the basis of this preliminary data, there is an incidence rate of 60 lower extremity injuries/100 PY during Army ROTC PT. It was also revealed that footwear and activity in and out of ROTC have no implications on risk of lower extremity injury. However, because of lack of equal distributions in each footwear condition, this needs to be further explored. Also, because we have found that younger cadets are at a much higher risk of injury than their older counterparts, preventative measures should be focused toward them. Because our results reveal that injury risk increases each year after an MSI is injured, prevention efforts will potentially help to reduce risk as they progress through a ROTC program.

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