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Impact of a Single Injury Prevention Instructional Session on the Incidence of Injury among U.s. Army Rotc Cadets

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IMPACT OF A SINGLE INJURY PREVENTION INSTRUCTIONAL SESSION ON THE INCIDENCE OF INJURY AMONG U.S. ARMY ROTC CADETS

JOSHUA WOOLDRIDGE

92 Pages

Background: Musculoskeletal injuries are the leading health concern for the United States Army. These injuries are the third leading cause of hospitalizations for Army service members and the primary cause for the majority of service-connect disability discharges. Over 80% of musculoskeletal injuries are overuse injuries caused by physical training. The Joint Services Physical Training Injury Prevention Work Group considers education to be a mandatory component of all injury prevention efforts; however, little military research has investigated the impact of education as a primary intervention.

Objective: To examine the impact of an injury prevention education class on the incidence of injuries in Reserve Officers' Training Corps (ROTC) cadets at a Midwestern university.

Study Design: Quasi-experimental, time-series study using a historic control group.

Methods: Seventy-nine ROTC cadets (age: 20±2 years, body mass: 73.57±12.60 kg, height: 172.88±9.50 cm, 26 females, 53 males) during the fall 2018 academic semester provided informed consent to participate in the study. Cadets within the same program from the previous fall semester served as the historic control group. A one hour and 15-minute long injury prevention class covering physiology of overuse injuries, common risk factors, and recommended interventions was taught to the cadets at the start of the semester. A second, 45-

minute class covering modifications to physical training programming was taught to those cadets in leadership roles. Injury data on any cadets that suffered an injury during both semesters were collected from athletic trainers working with the ROTC program.

Results: No change in the number of injuries existed between the control (n = 16) and intervention (n = 15) groups. Chi square tests of independence were performed between the two groups based on the nominal categories of body region injured, sex of the injured cadet, and whether the injury was caused by acute or cumulative trauma. No statistical significance between the groups was found based on body region injured (χ^2 (9) = 9.38, p = 0.403) or sex (χ^2 (1) = 2.78, p = 0.095). A statistically significant difference existed between the two groups based on the type of injury (χ^2 (1) = 3.89, p = 0.049).

Conclusion: The results of this study demonstrated no impact of injury prevention education as the sole intervention on the incidence of injuries in ROTC cadets. However, a shift in primarily overuse injuries to primarily acute injuries did occur, warranting further research on this topic.

KEYWORDS: Musculoskeletal injury, Injury prevention, Prevention education, Military injuries

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CONTENTS

TABLES

Table Page

FIGURES

Figure | Page

CHAPTER I: INTRODUCTION

The United States Army requires soldiers to be at their physical best for duty and combat. However, musculoskeletal injuries may be considered the most significant health threat to mission readiness,[1,2] leading to substantial manpower losses and healthcare costs for the Army.[3–5] On average, soldiers suffer 600,000 musculoskeletal injuries annually, predominantly to the lower extremity.[3,6,7] Repetitive overuse movements – linked directly to physical training – produce the majority of these injuries.[6,8] Physical training improves physical fitness and combat performance; however, mission readiness also requires healthy, injury-free soldiers.

The Defense Safety Oversight Council's (DSOC) Joint Services Physical Training Injury Prevention Work Group serves to improve the U.S. military's ability to prevent and treat musculoskeletal injuries.[6] The Work Group employed a public health-based approach to identify key risk factors, effective prevention strategies, and future research directions.[6] In a systematic review by Bullock et al,[9] the Work Group identified four critical components of an effective injury prevention program: research and program evaluation, surveillance, leadership support, and education. In 2015, soldiers and Army civilian employees responded to a U.S. Army Public Health Center (APHC) survey with requests for professional guidance and educational materials on injury prevention strategies.[10] "Educational materials" may include brochures, posters, fact sheets, technical reports, or journal articles delivered through electronic or printed media. Respondents to the APHC survey preferred fact sheets and brochures accessed by computer or as pre-printed materials[10] while the research referenced by the Work Group[9,11] primarily used classroom instruction for successful injury prevention.

Many responses to the survey also cited a lack of leader knowledge on injuries as an addressable barrier to injury prevention and rehabilitation.[10] Despite the Work Group's classification of education as an integral component to injury prevention, little Army research has been conducted on the influence of education on injury rates.[9,11–14]

Therefore, the purpose of this study was to investigate the impact of injury prevention education on the incidence of injuries in U.S. Army Reserve Officers' Training Corps (ROTC) cadets. The authors hypothesized that an education course based on the working group's prevention recommendations[9] would lead to a decrease in the rate of injuries experienced by ROTC cadets.

CHAPTER II: LITERATURE REVIEW

Identifying the Problem

The men and women that serve within the United States Army are the organization's greatest asset. The Army – like all branches of the U.S. military – requires service members to be regularly tested on a variety of physical fitness components to assess an individual's capability to perform duty and combat-related tasks.[15,16] Physical fitness is considered essential for combat readiness; therefore, the Army places great importance on physical training and expends considerable resources to ensure all personnel attain, and then maintain, high levels of physical fitness.[15,17] As with highly active populations, training-related injuries result from increased activity.[18] Over the last two decades, it has been scientifically recognized that musculoskeletal injuries are not only common in the Army (and the U.S. military as a whole), but may pose the greatest threat to service members, eroding combat readiness more than any other health condition.[3,8,19,20] While human performance optimization is integral to the Army, it is critical to not only enhance fitness, but to prevent training-related injuries to improve combat readiness.[15,21,22]

The goal of this review is to expand on the need for injury prevention measures in the United States Army. The Army Public Health Center relies on a five-step approach to interventions: (1) determine the magnitude of the problem; (2) identify causes; (3) determine prevention measures; (4) implement prevention programs; and (5) monitor and evaluate effectiveness of prevention efforts.[3,23–25] This review will highlight existing literature on injuries in the Army and prevention recommendations. In addition, this review will illustrate the impact of education as a form of injury prevention as well as expand on perceived barriers to injury prevention.

Incidence

Musculoskeletal and orthopedic injuries are the most significant detriment to medical and combat readiness of service members and have been for decades.[1,3,18,26,27] Military injury rates are 2.5 – 21 times higher than the general population depending on the specific injury.[28–35] For example, knee injuries are 10 times more likely to occur in members of the Army than the general population of the United States.[36] Comparing military injury rates[37–41] to the injury rates of civilian athletes[42–50] provides insight into the magnitude of the problem in the military. Military injuries occur at a higher rate than injuries to athletes competing in endurance sports, but are typically lower than the injury rate for contact sports.[24] Those serving in the U.S. Army, especially enlisted members, are at significantly higher risk compared to the other branches of service, accounting for over 40% of all Department of Defense injuries.[5,27,51]

Nearly 50% of service members experience one or more injuries each year, and more than half of the injures are physical training-related.[4,19,37] Most training injuries are not catastrophic, though they can be very debilitating.[5] Overuse injuries (predominantly of the lumbar spine, knees, and lower leg) account for more than 80% of all injuries.[7,8,27,51] Unintentional injuries account for more Army hospitalizations than any other category of diagnoses.[3] Training-related musculoskeletal injuries are the third-leading cause of hospitalization after falls and motor vehicle accidents.[3] Musculoskeletal injuries result in over a million outpatient medical encounters annually.[1,3,52] Training injuries cost over $100 million each year in medical care.[36,51] Athletic injuries also cause over 50% of disability discharges among U.S. Army service members.[24,53,54] Training-related injuries lead to more limited and lost duty days than all other conditions (e.g., combat-related injuries, illnesses, and motor vehicle accidents).[55,56]

Risk Factors

Injury occurrence is a multifactorial event. Injuries are the traumatic result of acute or chronic transfer of energy to bodily tissue leading to physiological damage and loss of functional capacity.[51,57,58] A critical step in the prevention process is to identify the underlying causes of injury in order to develop effective prevention measures.[23,59–61] Injuries result from a complex interaction between internal and external risk factors and mechanisms of injury. Risk factors describe situations in which individuals may be more likely to suffer an injury.[57] Risk factors alone may leave an individual more susceptible to injury, but the presence of risk factors will not cause injury to occur without a further mechanism. Injury mechanisms are the physical processes that provoke tissue damage, comparable to the failure of a machine.[58,62] Successful prevention efforts depend upon identification of risk factors that may be modified in hopes of decreasing susceptibility to injury. This effort is made more difficult for the U.S. Army as overuse injuries are the result of the cumulative impact of several micro traumatic events or may be chronologically distant from the injury mechanism.

Intrinsic Factors

Intrinsic risk factors are internal characteristics of an individual that increase their risk of injury.[57] A wide variety of intrinsic risk factors have been identified in Army service members. Caucasian soldiers experience more injuries than any other ethnic origin.[24,63] Past injuries significantly increase the risk of subsequent injury.[18,37,61] Research has commonly found low frequency of physical activity prior to entering the military to increase the risk of training injuries,[37,38,55,64–69] most likely caused by a sudden increase in activity during entry-level training. Several anthropometric factors have been linked to injury risk including a larger Q-angle,[70] genu valgum,[71] pes cavus,[24,72] rearfoot inversion,[73] shorter than average tibial length,[73] restricted ankle dorsiflexion,[74] and excessive external rotation of the hip.[5,75–77] Leg length differences and genu recurvatum have not been associated with increased risk of injury in military populations, and those soldiers with flat feet have been identified to be at the lowest risk of lower extremity injury.[5,37] Certain anatomical variations may contribute to injury risk by altering how the body absorbs forces during high-impact activities such as running. Lower levels of muscular endurance as measured by push-up performance is the second most commonly identified risk factor for military training-related injuries.[65,78,79] Those soldiers who perform fewer push-ups on the Army Physical Fitness Test (APFT) are at greater risk of injury. Despite the common belief that stretching and increased flexibility provide injury protection,[10] flexibility constitutes a bimodal risk factor.[37,80] Individuals at both low and high extremes of flexibility show more than twice the risk of injury compared to those of average flexibility.[65,66,68,70]

Sex has been consistently shown to correlate with injury rates. Female Army trainees experience almost twice as many injuries as men in the same training program.[63,64,75,81–83] However, women in operational units have not been shown to be at higher risk.[5,41] This discrepancy between injury rates of females trainees versus female service members may be explained by the fact that on average, women entering military service tend to be less physically fit than men at the start of initial entry training.[5] Across both training and regular unit populations, when cardiorespiratory fitness is controlled for, women suffer injuries at similar rates to men in the Army.[18,84,85]

Age has been investigated as a risk factor in a variety of settings and Army populations, but findings have been inconsistent. Multiple studies[86–89] have found no association between age and injury. Research conducted in training environments, especially basic combat training and advanced individual training, shows older individuals are more likely to sustain injuries.[18,27,37,63,68,70,90] In contrast, soldiers in operational environments show a decreasing trend for injuries with increasing age,[41,55,91] which is consistent with data from civilian populations.[24,92] Older individuals entering the Army may be less physically prepared for the demands of entry-level training, leading to increased injury rates.[24,66,75] However, in the Army as a whole, older soldiers tend to have been in the military longer. Consequently, they typically are of higher rank and may be in supervisory roles. Their positions may not expose older soldiers to the same occupational and physical training demands as younger service members.

Much like the previously discussed topics, research on the association between body mass index (BMI) and injury risk has been contradictory.[5,79,93] Some research has indicated there is no association between BMI or body fat percentage and risk.[65,75,94] Other studies have shown an increased risk with increased body mass.[27,61,90] Most research suggests both high and low body weight extremes have an association with injury risk,[64,66,95] with individuals of lower BMI being at the greatest risk.[19,96] Individuals with low BMI may have less muscle mass or bone density, predisposing them to injury resulting from strenuous load bearing.[93,97,98]

Tobacco use, especially cigarette smoking, significantly increases injury risk in Army populations, even when other factors are controlled.[37,65,67,75,99–101] The amount of smoking appears to have a linear relationship with higher injury risk.[84,86,102] Smoking negatively affects wound healing and increases susceptibility to injury even after smoking cessation.[103–107]

Lower aerobic fitness has shown strong and consistent association with increased injury risk.[80,86,97,101,108] Typically in research on Army populations, slower times on the APFT two-mile run are used to operationally quantify aerobic fitness;[55,78,101,102] however, some research[65] has measured peak VO_{2max} directly. Soldiers with low aerobic fitness may perceive duty and training tasks as more difficult.[109] Those less fit will perform activities at a higher ratio of their maximal aerobic capacity, fatigue more rapidly, recover slower, and have a lower threshold for prolonged activity.[19,110] Fatigue may result in altered motor patterns,[111,112] leading to uncustomary musculoskeletal loading and greater physiological stress during exercise.[65,93,113,114]

Extrinsic Factors

The benefits of exercise are well established,[37] and physical training is unavoidable for individuals in the Army.[15,16,27] Type and amount of exercise are the primary extrinsic risk factors for military injuries.[18,68,115,116] A significant dose-response relationship exists between vigorous weight bearing activities and injury rates.[44,68,94,117] Running remains the leading cause of injury in the Army followed by road marching and obstacle courses.[5,19] Marching-related injuries pose five times the risk per unit of time compared to running, and the risk of injury from obstacle courses was seven times that of running per unit of time spent performing the activity.[115]

In the Army, cardiorespiratory fitness has been viewed as synonymous with overall military performance, leading to an overemphasis on running in physical training programs.[2,22] A wide body of evidence demonstrates that high running volume drastically increases the risk of injury.[37,42,44,68,94,118–128] Rapid increases in running volume increase injury risk.[5,93,129] One study[130] found that runners who increased weekly distance more than 30% per two weeks were at increased risk of injury compared to those who progressed by less than 10% during the same time period. Running for a duration of 45 minutes versus 30 minutes per session increases injury risk disproportionately to fitness improvements.[93,117] Soldiers that exercise 10 or more hours per week are also at increased injury risk.[18,41] Running more frequently than three days per week results in significant increases in injury rates,[93,117,131] with running five times per week inflating risk 225% with no significant change in aerobic fitness when compared to three times per week. Mileage shows the strongest association with injury risk.[47,68,132] Those who run greater distances per week experience more injuries.[24,44,101,117] One study[133] observed that those who ran more than 20.1 kilometers per week (km/wk) were at increased risk. Jones et al.[68] found that infantry trainees running 17.7 km/wk suffered 27% more injuries than those running less than 8.0 km/wk and performed worse on the APFT over the course of the study. Grier et al.[134] reported that soldiers running more than 25.7 km/wk experienced more than twice as many injuries as soldiers running eleven or fewer kilometers per week. Running is an effective means to improve cardiovascular fitness; however, physiological thresholds exist above which increased running results in more injuries.[68] As frequency, duration, or total amount of training increase, injuries also increase until a point is reached at which injury rates continue to escalate substantially while aerobic fitness no longer improves.[18,117] Combining physical training with demanding military training and duty may cause soldiers to exceed these limits faster than traditional exercise alone.[37]

Prevention

While some level of injury will always be a cost of physical training,[5] prevention of training-related musculoskeletal injuries should be the Army's number one priority.[8] Performance optimization must balance maximizing fitness outcomes with minimizing injury risk by implementing evidence-based prevention strategies.[2] Once risk factors have been identified, measures must be introduced to reduce future injury incidence and be evaluated for effectiveness.[57,135] Altering intrinsic risk factors presents a challenge for the Army in that modifications must be implemented before beginning physical training; however, extrinsic factors are more easily amenable to intervention.[18] Ultimately, prevention requires a combination of efforts as modification of any single factor will most likely have a minimal impact on its own.[5]

Current Army Recommendations

In 2010, the Defense Oversight Council's Joint Services Prevention of Physical Training Injuries Work Group (hereafter referred to only as the "Work Group") identified four essential elements of any successful prevention program: education, leadership support, injury surveillance, and program research and evaluation.[9] The Work Group also identified multiple intervention strategies with research strongly supporting the effectiveness of the interventions. Successful interventions included decreased running volume, incorporation of neuromuscular-based training, appropriate nutrition, the use of mouth guards and rigid ankle braces during high-risk activities, and wearing synthetic socks.

Leadership Support

Preventing injuries depends on the commitment of Army leaders to being familiar with risk factors and the intervention process.[1] Army commanders can impact unit injury rates by being aware of the current state of injuries, understanding risk factors, actively setting goals to improve, and monitoring unit success.[9] Leaders must recognize signs of overtraining such as increased injury rates and decreased performance (decreased APFT pass rates or slower average run times)[37,136] and respond appropriately to these signs by modifying training plans. The need for leadership responsibility and accountability cannot be overstated. When leaders are held accountable for the well-being of their subordinates, injury rates decrease and progress improves.[9]

Education

The fourth step of the injury control process is to share data gathered from research.[24] Information must be disseminated to those who may directly use that knowledge to prevent injuries. The Work Group considers injury prevention education an essential component of any successful program.[9]

Civilian research has shown limited success in injury education provided through informational materials such pamphlets, videos, and flyers;[137–143] however, education in combination with neuromuscular interventions have shown positive influence on injury incidence.[144–146] The Army recommends a "community-based approach" to injury prevention education.[26] This approach tailors information to the perceived needs of the specific community and combines educational efforts with community leadership participation to modify attitudes and behaviors.[11,13,147–149] Knapik et al.[11] provided seven hours of classroom instruction on injury awareness and prevention to unit staff and to advanced individual training (AIT) student-soldiers prior to the start of training. The course detailed physiology, conditioning concepts, injury prevention techniques, and application of risk management. Alongside the prevention education, the soldiers transitioned to the newly developed Army physical readiness training (PRT). Beginning in 2008, during the official transition to PRT, Scott et al.[14] provided recommendations on injury prevention to senior military leaders at Fort Jackson. Those recommendations led to formal injury prevention training being added to the curriculum of leaders at Fort Jackson's pre-command training. Early implementation of Army PRT as a replacement for traditional physical training involved educating military commanders and unit-level leadership at BCT locations on injury prevention and training modifications as well as establishing connections with potential injury prevention partners across multiple disciplines (preventive medicine, physical therapy, occupational health, health promotion, safety).[14,150]

Surveillance and Evaluation

Injury surveillance systems are critical for long term injury prevention for a variety of reasons.[151,152] Surveillance provides data for the identification of injury priorities and allows for evaluation of intervention effectiveness.[1,9] Without medical surveillance, prevention outcomes cannot be measured with any certainty.[24,153] Program evaluation not only allows for reviewing implemented prevention measures but can guide future research and intervention protocols.

Prevent Overtraining

Sound programming of physical training should prevent overtraining to reduce the risk of musculoskeletal injuries. Safe and effective physical conditioning programs consider all physical stressors experienced by trainees including training and daily duty activities and are structured in such a way as to minimize negative impacts of strenuous exercise. The most obvious training intervention to mitigate injuries in the Army is to reduce the amount of running performed by service members.[9] The amount of running may be dramatically decreased to prevent injuries without adverse impact on soldier cardiovascular fitness.[154–157] In one Army study,[24] a 40% reduction in running mileage resulted in a 54% decrease in injury rates. Other studies[68,158] have shown 25-30% reductions in injury incidence after reducing running mileage with minimal impact on APFT run times. Performance on fitness tests can be used to separate soldiers into ability-based training groups with physical conditioning tailored to an appropriate level based on current fitness.[158] Running should start with very low mileage and progressively increase distance and speed to allow the body to adapt to the increasing demands.[11,158–165] Using time rather than distance to program running would allow less fit soldiers to run shorter distances than their faster, fitter comrades. Such a programming style accommodates low and high fitness individuals simultaneously under a single training protocol. Periodization of physical conditioning, characterized by alternating periods of high and low intensity training in a planned manner, may be used to optimize performance and minimize injury.[166,167] Cardiorespiratory fitness may also be improved by many aerobic activities other than running such as walking, swimming, or the use of aerobic endurance machines when appropriate facilities and equipment are available. Interval training can be implemented to train the cardiovascular system while minimizing ground-contact stress on the lower extremity. Interval training combined with a reduction in total running mileage has shown aerobic fitness improvements greater than sustained running and reduced injury risk.[11,15,158,168,169] Many of these changes are recommended by the Army's field manual for physical readiness training, *FM 7-22*;[15] however, guidelines from the document may not be followed or enforced at the unit level.

Neuromuscular Training

Neuromuscular training utilizes exercises focused on core stabilization, proprioception, multi-axial movements, and agility drills such as lateral running, pivoting, jumping, and landing to improve awareness and control of the joints.[9,93] A profound amount of research supports the conclusion that neuromuscular training reduces injuries in sporting activities.[170–200] Such proprioceptive training protocols have been shown to reduce injury incidence by up to 30% in military populations.[11,158,160,201] Beyond improvements in proprioception and motor control, neuromuscular training in the military may reduce risk for a variety of other reasons: (1) incorporating these activities reduces exposure to other physical conditioning, especially running; (2) musculoskeletal stress is more distributed across the body due to the multi-planar and multi-axial nature of the drills; and (3) strength and stabilization exercises through diverse movement patterns better prepare soldiers for the complex and unpredictable tasks experienced in Army occupational and combat duties.[9]

Nutrition

Physical activity depletes the body's glycogen stores which is linked to reduced strength, fatigue, muscle damage and increased risk of injury.[202–205] Original nutritional research[204–210] and systematic reviews[202] suggest that replenishing muscle glycogen lowers markers of muscle damage after physical activity. Following strenuous activity, the metabolic environment is optimized for replenishing metabolized glycogen by consuming a combination of carbohydrates and protein within 60 minutes to initiate repair of muscle damage.[203–205,209–211] According to the Work Group, the ideal balance of post-exercise nutrients to accelerate recovery is "roughly 12 to 18 grams of protein and 50 to 75 grams of carbohydrates."[9] However, other research[203,212,213] would suggest such numbers should not be provided as a range, but instead based on an individual's body mass. Based on the International Society of Sports Nutrition recommendations,[203] 0.2 – 0.5 g protein per kg body mass and 1 – 1.5 g carbohydrates per kg body mass may be a more appropriate recommendation than a range of specific macronutrient amounts.

Mouth Guards

Orofacial injuries are common in vigorous activities, and mouthguards are mandated protective equipment in many contact sports.[214] Studies that have compared mouthguard users and nonusers in sports support the concept that mouthguards reduce the incidence of orofacial injuries.[215–223] Army service members participate in a variety of activities that pose the risk of orofacial injuries. Research conducted during basic combat training (BCT) found that pugil stick training, bayonet training, hand-to-hand combat training, and obstacle course training were the most likely activities to lead to facial injuries. The use of mouthguards during these training activities drastically reduced the number of dental injuries during training.[224,225]

Rigid Ankle Braces

Epidemiology for ankle injuries is well studied.[226–232] Ankle braces have consistently shown to be effective in reducing ankle injuries during high-risk activities by greater than 50%.[226,233–239] Among athletes, ankle braces provide the greatest protection for those who have suffered previous ankle injuries, but remain effective as a prophylactic measure as well. During U.S. Army airborne operations, the majority of injuries involve the ankle.[226] Wearing ankle braces during airborne jumps led to an 85% decrease in injuries per 1,000 jumps compared to those where braces were not worn.[226] Research in the U.S. Army Rangers over a three-year period demonstrated that injuries were three times higher among those not wearing ankle braces.[236] Despite the effectiveness of ankle braces as an intervention, the Army discontinued their use over concerns of cost. During the time after ankle braces were discontinued, severe ankle injuries rose by 70% before the ankle brace was reinstituted for airborne training.[235] The Work Group recommends the use of ankle braces during high-risk activities such as parachuting or long-mileage road marching, especially in individuals with a history of ankle sprains.[9]

Synthetic Socks

Friction against the skin may lead to blister formation, which can be exacerbated by moisture such as sweat.[240–245] Hydrophobic socks designed to reduce foot moisture appear to reduce blister formation.[246–249] Wearing a polyester or polyester blend sock draws moisture away from the skin, reducing the rate of blister injuries by 56%.[9]

Interventions Not Recommended

Numerous interventions exist that the Work Group does not recommend simply due to a lack of strong evidence supporting the intervention's efficacy as an injury prevention measure. However, some interventions are not recommended due to either a lack of evidence of proven injury prevention (stretching and back braces) or evidence of potential harm (nonsteroidal anti-inflammatory drugs).

Stretching

Stretching prior to exercise is commonly advocated for as a method to reduce risk of injury.[156] Static stretching has benefit for increasing muscle flexibility and providing temporary pain relief;[250–254] however, several systematic reviews have reached the same conclusion that neither stretching prior to nor after exercise reduces the risk of injury.[255–258] The Work Group does not consider it to be prudent to recommend indiscriminate stretching among service members.[9]

Back Braces

Back braces have been promoted as a preventive measure against spinal injuries in healthy populations. This recommendation has not been substantiated in scientific literature.[9] The Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, the Occupational Safety and Health Administration, and the Office of the Surgeon General do not promote or support the use of back braces as personal protective equipment.[259,260] A systematic review in 1997 concluded no evidence to advocate for the effectiveness of such devices on the prevention of back injuries.[261] Since then, at least two other literature reviews reached the same conclusion that lumbar braces are not effective as primary or secondary prevention measures.[262,263] The Department of Defense (DoD) specifically prohibits the use of back braces for prevention.[264] Based on the evidence of ineffectiveness and lack of support from government health agencies, the Work Group does not endorse the use of back braces as an injury prevention intervention.[9]

Anti-inflammatory Medications

It is hypothesized that nonsteroidal anti-inflammatory drugs (NSAIDs) may control the inflammatory response induced by muscle contractions to prevent tissue damage.[9] However, NSAIDs cause more than 75,000 hospitalizations and 7,500 deaths in the U.S. annually.[265] While one study[266] demonstrated reduced exercise-induced skeletal muscle damage when administering pre-exercise NSAIDs, most research shows inconsistent results[267] or no effect on muscle soreness or markers for muscle damage.[268–270] Furthermore, NSAID use poses multiple harmful risks, including gastrointestinal bleeding, ulceration, kidney failure, and liver damage.[271–273] The most common side effects are gastrointestinal responses such as stomach discomfort, bloating, cramping, pain, acid reflux, and diarrhea or constipation.[274] These symptoms would obviously limit performance during exercise and physical activity.

Knowledge of the Problem

Barriers to Prevention

The largest challenge in implementing prevention protocols is integrating efforts into the daily activities of training and eliciting the support of the Army leadership and soldiers as a whole.[5] Non-traumatic injuries may not be acknowledged as a “legitimate” issue, leading to a common belief that focusing on training injuries is unnecessary.[26,61] The military mindset of exceeding training standards at any cost has created a notion that overuse injuries are an inherent consequence of being in the Army and are a means to “screen out the weak”.[7,10] Overcoming this attitude is necessary to improve awareness of the negative impacts of training-related injuries on Army combat readiness. If a lack of knowledge of the problem and its causes are used as justification to diminish the scope of the situation, prevention measures may be ignored or improperly carried out.

According to a survey conducted by the APHC, the most frequently raised concern regarding injuries was Army leadership.[10] Approximately 44% of respondents agreed that Army leadership emphasized the importance of injury control; however, just under one third of respondents stated leaders held negative views or did not show support for injury prevention or rehabilitation.[10] Soldiers and Army civilian employees described leaders as lacking knowledge on the Army's injury rates and as not recognizing critical prevention guidelines.[10] Leaders at the unit level were characterized as encouraging overtraining, marginalizing those who are injured, and requiring injured or formerly injured individuals to perform tasks likely to result in further health complications.[10] Inadequate leader understanding of reconditioning and recovery exacerbates the training-related injury problem. While there are no simple cures, military leaders must understand that musculoskeletal injuries are largely preventable, and they must put forth efforts to optimize both health and physical performance.[5,9,21]

Another possible challenge facing prevention efforts is the chance of risk homeostasis where the end result of introducing a prevention measure is an unwanted outcome such as no change or an increase in injury risks.[57]

Education as Prevention

When responding to the previously mentioned APHC survey, many soldiers could not correctly identify risk factors and interventions related to musculoskeletal injuries.[10] Current Army policies do not require injury education at any level of a soldier's professional, occupational, or leadership training.[10] A common response in free-text comments suggested that training – especially for unit leaders – on injuries should be provided by the Army.[10] Other responses indicated a desire for training and educational materials regarding common musculoskeletal injuries, overtraining, and professional guidance about injury prevention.[10]

Evidence of injury risk factors, mechanisms, and prevention efforts documented only in scientific literature does not reach the general Army population or change the behaviors and attitudes of soldiers.[26]

While it is difficult to measure the impact of education alone on injury rates, providing military commanders with instruction on proven injury control strategies is vital to aid the Army's responsibility to protect service members.[11,12,177] The content and delivery of such education should center on improving injury awareness, injury causes, and appropriate management of injuries to enhance the effectiveness of any prevention strategy. Injury prevention education must be planned around the framework of specific activities that contribute to common injuries including information on risk factors.[10] Instruction should cover injury awareness, injury control techniques, physiological principles, and application of risk management.[11] Guidance should also be provided on concepts of proper physical conditioning, exercise technique, and avoidance of overtraining.[5]

The most important aspect of musculoskeletal injury prevention is the education of Army leaders in safe and effective methods for training and proper injury management.[5] The influence of leadership awareness on injury incidence in military populations cannot be understated.[11,14,275] Higher Army commanders and military policymakers must be informed on all aspects of training-related injuries to enable them to disseminate information, implement injury prevention requirements, and guide Army-wide changes toward effective intervention.[5,10] Broad changes may be applied by high-ranking general officers, but prevention measures will fall short without the influence and accountability of company grade commissioned officers and noncommissioned officers. As senior enlisted soldiers, noncommissioned officers have direct oversight of physical training. If provided additional education, unit leaders could guide junior soldiers in areas of injury prevention and rehabilitation. Army injury prevention efforts are most effective when training, application, and enforcement are applied at the unit level.[26]

Despite considering education essential for prevention, the Army has never investigated the impact of education as a prevention measure on its own, only in conjunction with other interventions such as training modifications.[9,11,12,14] Education on prevention would not only need to improve injury awareness but overcome the organizational culture within the Army that views injuries as inconsequential.[12]

Conclusion

A wide body of literature supports the claim that physical training-related injuries are the greatest health threat to the modern U.S. Army. Training-related injuries are the leading cause of lost duty, hospitalizations, and disability discharges.[9] Research has identified modifiable intrinsic and extrinsic risk factors and evaluated effective prevention strategies.[3,9,98,151] However, this data has been published in scientific literature with little information being disseminated to Army service members.[26] Many soldiers expressed beliefs that a lack of knowledge on prevention and recovery contribute to musculoskeletal injury rates. While education is considered a vital component of injury prevention, little evidence exists reviewing the effectiveness of education on injury incidence in the Army. By quantifying a relationship between education and injury rates, literature can begin to examine the practical impact of education as a prevention tool in military populations. The aim of this study was to investigate the impact of an injury prevention class on injury rates when compared to a historic control group in a military population.

CHAPTER III: METHODS

Study Design

The current study used a quasi-experimental design that implemented a historical control group. Injury rates of ROTC cadets in the semester following the educational course were compared to injury rates of cadets in the same ROTC program from the fall semester of the previous academic year. Using recent prior injury data from the same ROTC program minimized initial nonequivalence of the control and intervention groups while providing access to the injury prevention education materials to the entire ROTC program.

Participants

Study participants included Army ROTC cadets enrolled at a Midwestern university. Researchers chose ROTC cadets through convenience sampling to represent the Army population. ROTC cadets are the future leaders of the Army as the majority of officers commission through college ROTC programs.[276] Military research commonly selects from the following sampling frames: special operations warfighters,[277,278] basic combat training recruits,[65,279] and officer cadets[144,280] (typically from one of the major military academies). While not yet in the military, ROTC cadets experience similar stressors to average military members in a garrison environment such as training exercises, physical readiness training, inter-unit competitions, tactical training, and field training exercises alongside the challenges of being a college student.[281,282] For these reasons, the authors believed ROTC cadets adequately represented a military population for the operations of this investigation.

A total of 79 ROTC cadets (26 females, 53 males) consented to participate in the current study by allowing investigators to access their injury and APFT records. Injury data were collected from the two athletic trainers working with the ROTC on all musculoskeletal injuries that occurred during the Fall 2017 and Fall 2018 semesters. APFT information was provided to investigators by ROTC cadre in the form of official APFT score cards. Table 1 contains average demographic information about the cadets. Cadets in the Fall 2017 semester served as the control group while cadets in the Fall 2018 semester served as the experimental group. No randomization was performed between the two groups. Preliminary analysis revealed no significant differences between the control and experimental groups based upon age, sex, height, weight, or APFT performance.

Injury Prevention Course

Prior to the injury prevention education class, cadets completed a survey on their current level of injury prevention knowledge as well as areas they would like to learn more about. With permission, the authors of the current study used a sample of questions from the APHC Injury Prevention Survey.[283] Selected questions were modified to reflect the ROTC population rather than the Army as a whole. Survey questions concerned cadets' current knowledge of injury risks and areas of injury prevention and rehabilitation where they would like to learn more. Cadets also completed a short, 10-question quiz covering similar topics prior to the course.

The injury prevention education course was taught by one of the authors in a classroom setting at the start of the 2018 fall semester. The course consisted of a single class lasting approximately one hour and 15 minutes presented to the entire ROTC program. Information provided during the class covered the Army's injury statistics, the link between physical training and musculoskeletal injuries, and the working group's recommendations on injury prevention.[9] The class emphasized injury risk factors,[65,284] the prevention of overtraining, and the performance of "multiaxial, neuromuscular, proprioceptive, and agility training."[9] The class also included information on topics the APHC survey[10] found to be key areas where knowledge was lacking, such as the bimodal injury risks related to flexibility and body mass. At the close of the class, participants completed a second survey and quiz that included the same questions as those taken prior to the course to provide metrics to measure learning that may have occurred as a result of the class.

A second, 45-minute long class was given to those cadets serving leadership roles within the ROTC program as platoon sergeants, platoon leaders, company first sergeant, company commander, battalion command sergeant major, and battalion commander. The second class covered two primary topics. First, that when military leaders take an active role in prevention efforts, interventions are more successful.[9,275] Second, more detailed recommendations on physical training alterations were provided based on guidelines from *Field Manual 7-22,*[15] the American College of Sports Medicine,[285,286] the National Strength and Conditioning Association,[287] and previous research[277,288,289] on Army training changes.

Injury Data Collection

Injury data were collected on all patients seen by the athletic trainers (ATs) working with the university's ROTC program. The APHC defines injury as "the damage of or interruption to the normal functioning of body tissues that results when an energy transfer exposure exceeds the threshold of tissue tolerance either suddenly (acute traumatic injury) or gradually (cumulative micro traumatic injury)."[290] For the purpose of this study, injuries were operationally defined as tissue damage or dysfunction that partially or fully prevented cadets from participation in the ROTC military physical conditioning class for at least one day. Recorded injury information included body region, diagnosis, and whether the injury was due to an acute or chronic onset. Bilateral injuries impacting the matched contralateral region with the same mechanism and diagnosis were classified as a single injury (e.g., medial tibial stress syndrome experienced in both legs simultaneously would be considered a single injury). Recurrent or repeated injuries to the same region with the same diagnosis within the same semester were recorded as a single, chronic event rather than multiple injuries. Reported injuries were evaluated either on-field at the designated activity site or in a clinical setting at the university's athletic training clinic.

CHAPTER IV: RESULTS

Results

Course Content Quiz

Of the ROTC cadets that participated, 69.6% (n = 55) completed the 10-question, multiple choice quiz prior to the injury prevention class and 77.2% (n = 61) completed the same quiz after the class. Figure 1 displays the percentage of correct answers to each question for both quizzes. The average correct answers on the quiz prior to the class was 40%. Most concerning were the answers to the first two questions on the quiz ("Which of the following is most responsible for running-related injuries?" and "True or false: Stretching prior to exercise has been shown to decrease injury rates."). Only 9% of cadets responded to the first question correctly, and fewer than 4% correctly answered the second prior to the course. After the class, 57% and 72% of cadets provided the correct answer for the first question and second question, respectively. The average score on the quiz after the injury prevention class was 70%. Two questions ("When adjusted for time [ ] leads to the most injuries." and "[ ] is the greatest predictor of injury in the Army.") did not see a positive change in the number of correct responses. Prior to the class, 33% and 65% of cadets provided correct answers for these two questions respectively, while only 20% and 61% did so after the class.

Survey Responses

Of the participating ROTC cadets, 68.4% (n = 54) completed the modified APHC survey[10] prior to the injury prevention class and 72.2% (n = 57) completed the post-course survey. Cadets rated their aerobic endurance and muscular strength using a 5-point Likert scale. The responses to those questions may be found in Figure 2 and Figure 3. On the pre-class survey, 21 cadets stated they had suffered an injury in the previous 12 months. The self-reported mechanisms for those injuries are included in Figure 4. Of those injured, over half (52%, n = 11) described overuse as the primary mechanism of their injury. One third (n = 7) of injured cadets reported running as the causal event for their injury. As part of both surveys, cadets responded to a question about the leading causes of injuries in the U.S. Army. The responses to that question from both surveys are found in Figure 5. Figure 6 and Figure 7 display the distribution of cadet 5-point Likert scale responses to two questions dealing with injuries in the U.S. Army. Figure 8 provides the proportion of cadet responses to questions concerning cadets' perceptions of leadership opinions on injury prevention divided by answers from injured and uninjured cadets. While injured cadets were more likely to disagree with survey statements about leadership prevention efforts, the average responses were similar between injured and uninjured cadets. The post-course survey included questions where cadets expressed the desire for further educational materials to be provided. Figure 9 and Figure 10 show the primary areas of interest. Both surveys included a series of questions dealing with a variety of injury risk factors and interventions that were reviewed by the Work Group,[9] ranked on whether cadets believed that the factor increased or decreased the risk of injury. The cadets' answers to these questions prior to the class may be found in Table 2. Table 3 shows the cadets' responses to the same questions after the course, with answers highlighted to indicate areas where further education or training may be needed.

Injury Data

During the Fall 2017 semester, 20.3% of participating cadets suffered an injury. Of the cadets included in the study, 19.0% were injured during the Fall 2018 semester. No differences existed in the number of injuries between the historic control group (n = 16) and the experimental group (n = 15). Table 4 includes a breakdown of cadet injuries over the two semesters. A chi-square test of independence was performed to compare injury frequency between the two groups based on the nominal categories of body region of the injury, sex of the injured cadet, and whether the injury was due to acute or cumulative trauma. No difference between groups existed based on the region of the body injured (χ^2 (9) = 9.38, p = 0.403). In the control group, more female cadets (n = 9) than male cadets (n = 7) were injured. In the experimental group, more male cadets (n = 11) were injured than female cadets (n = 4). However, there was no statistically significant difference (χ^2 (1) = 2.78, p = 0.095) found between the two groups based on sex. A significant difference (χ^2 (1) = 3.89, p = 0.049) was found between the control and experimental groups based on the type of injuries cadets experienced. The control group experienced mostly (69%, n = 11) cumulative injuries while the experimental group primarily suffered acute injuries (67%, n = 10).

Discussion

Musculoskeletal injuries due to overuse from physical training are the leading threat to mission readiness in the United States Army.[1,2,6] Little Army research has investigated the impact of education on the incidence of injuries in military populations.[9,12,201] Previous research has revealed that service members are not knowledgeable on injury risk factors or interventions,[10] potentially due to a lack of widespread distribution of scientific information to Army members.[26] The purpose of the current study was to examine the influence of an injury prevention class on the incidence of injuries in Army ROTC cadets. Our results found no significant difference in the number of injuries experienced by cadets the semester after an injury prevention course when compared to cadets within the same ROTC program the previous academic year.

Results of this study corroborate previous research on the use of education as an intervention in finding no significant decrease in injury risk.[137–139,142,143] Unlike the present study, which used classroom-based instruction, most previous educational interventions have primarily used printed materials(e.g., pamphlets, booklets, etc.)[137–139] or videos.[142,291] Only one other study has reviewed classroom instruction as the sole intervention;[143] although, unlike the current investigation, that research was conducted on children under the age of 10. In all but one[291] of the previous studies, educational materials and instruction did not have a significant effect on injury risk. Many factors such as course content, delivery method, the teaching experience of the investigators, or even the audience receiving the instruction may have had an impact on the outcomes of these studies.

Unlike the current study, numerous studies[144–146,292] have found education as a primary component of multi-factorial interventions to be successful. Research conducted in military populations has reached similar conclusions when combining mandatory injury education alongside other interventions such as changes to physical training and leadership support of the interventions.[11,13,14] These previous military studies found significant decreases in injury risks through their multi-factorial interventions. These studies combined classroom instruction, educational handouts, training changes, and injury surveillance to provide a robust intervention process that led to significant decreases in injuries. Perhaps the biggest factor was leadership support (a mandatory component of successful interventions)[9] in the form of enforcement of the prevention guidelines outlined in the educational materials and instruction. However, it is not possible to determine from this previous research which element of the multi-factorial interventions provided the greatest benefit. The results of these previous studies align with the Work Group's findings that education alone is difficult to measure as an intervention but is effective as one part of a multi-faceted approach to prevention.[9] While beyond the scope of this study, further research may be warranted to determine the effects in isolation of each factor that composed the interventions in these previous studies.

Potential explanations exist for the lack of impact from the educational intervention in the present study. In the successful multi-factorial interventions in military populations mentioned above,[11,13,14] the educational interventions were of considerable length, ranging from seven hours of classroom instruction[11] to multiple courses taught over throughout a college semester.[13] The present study only incorporated a single class on injury prevention to all cadets in the ROTC program and a second class to those cadets in leadership roles, totaling approximately two hours of content. On the post-course survey, most cadets expressed a desire to receive further information about topics discussed during the class (Figure 9 and Figure 10). It is possible that the range or detail of information provided was not enough to affect a significant change in the physical training-related attitudes and behaviors of the cadets.

The cadets' intrinsic risk factors may have also influenced the effect of the provided class on injury occurrence. Previous research has found a negative correlation between aerobic fitness and injury risk, where those trainees who are fitter are less likely to suffer injuries.[64,65,101,279,284] Based on the cadets' 2-mile run times (Table 1) and the cadets' self-reported aerobic endurance (Figure 2), cadets that participated in the current study are of relatively high aerobic fitness. Such a level of physical fitness may have had a protective effect against physical training-related injuries. When comparing the cadets' opinions on injuries (Figure 5 and Figure 6) and knowledge of injury mechanisms (Figure 4) and risk factors (Table 2 and Table 3) to the survey answers of service members and Army civilians in the study by Hauschild et al.,[10] the cadets that participated in the current study appeared to be better informed on injury risks and possible interventions prior to the classes provided. Previous injury increases the risk of future injuries, and the percentage of cadets that experienced injuries in the control and intervention groups was considerably lower than numbers reported in Army BCT trainees.[64,116] Based on these factors, it may be assumed that the majority of the cadets in our study were not at high risk of injury prior to the intervention being implemented.

While the results of this study did not support the authors' hypothesis, an unexpected result did occur. The total number of injuries between the control and intervention groups were almost identical; however, the control group saw primarily overuse injuries from cumulative trauma (69%, n = 11) and the intervention group experienced mostly acute injuries from single incidents (67%, n = 10). Similar results occurred in the research conducted at the Army War College by Knapik et al.[13] In that study, the use of an injury prevention booklet combined with prevention classes led to an overall decrease in the number of injuries that occurred; however, while the total injuries decreased, the number of acute injuries increased after the intervention. As a potential explanation, Knapik et al.[13] proposed that since their educational intervention focused almost exclusively on factors effecting sport and exercise-related overuse injuries it may not have had an impact on other sport-related injuries. Similarly, the current study focused on risk factors and interventions related to overuse injuries because Army service members predominantly suffer injuries due to cumulative stress from physical training. While this would support the decrease in overuse injuries, it does not provide evidence explaining the increase in acute injuries. It may be possible that training changes in response to the two classes increased the cadets' risk of certain acute injuries such as lower extremity muscle strains (the most common acute injury in the intervention group). However, the investigators of this study did not record data on the ROTC's physical training schedule. Therefore, no evidence exists from the current study to support such an explanation.

Limitations

The largest limitation of this study is the inability to provide causal information. Any changes found between the intervention and historic control groups could not have been directly caused by the educational material presented in the course; however, changes in injury incidence could have indirectly resulted from cadets altering their behavior and attitudes towards injury as well as modifying their physical training based on the information provided to them.

In this study, two classes were taught to the ROTC cadets, totaling approximately two hours of instruction. The experience of the investigator that designed and presented the instructional sessions may have affected the cadets' ability to learn and implement the provided information. In the study conducted by Knapik et al.,[11] seven hours of classroom instruction on injury prevention were provided alongside physical training modifications. Scott et al.[14] provided several briefings to the military commanders at Ft. Jackson over the course of several years and eventually had injury prevention education incorporated as a mandatory component of BCT leader and instructor training. While it may not have been feasible in the present study, the educational prevention efforts may have been improved using multiple courses given throughout the academic semester to allow for more in-depth instruction on the covered topics. A related limitation may have arisen due to the ROTC cadre (current military commissioned officers and noncommissioned officers serving as instructors within the program) did not attend the classes taught to the cadets. The lack of active participation from the cadre may have led to the cadets perceiving an absence of leadership support for the prevention effort; a mandatory component of all successful interventions according to the Work Group.[9]

An inability to record data on unreported injuries may have impacted the results of the current study. When responding to the pre-course survey, more cadets reported injuries than had been disclosed to the athletic trainer working with the ROTC program during the previous academic year. This may be attributable to the wording of the survey question; however, the possibility of cadets reverse malingering should not be ignored. Reverse malingering is a term originally coined to describe United States Air Force pilots denying medical issues to continue working in aviation.[293,294] Individuals reverse malingering may hide or downplay the severity of injuries for a variety of psychosocial reasons. Both staff athletic trainers that worked with the ROTC program reported being aware of cadets that did not seek, or refused, medical treatment of injuries. A previous study by Almeida et al.[295] found that of United States Marine Corps recruits, 11.6% of female recruits and 23.9% of male recruits did not report injuries suffered during initial military training. Little research has been conducted on this behavior in military populations, but such occurrences highlight the need for active injury surveillance efforts, especially when attempting to implement interventions.

Three other limitations in the present study were timeframe and sample size. Extending the time for data collection from the fall semesters to the full academic years would have provided more injury data to analyze. Likewise, the total sample size (n = 79) was adequate, but so few injuries occurred in the control and intervention groups that statistical power of the analyses performed may have been lowered. Sample size could have been increased by recruiting ROTC programs from other schools to participate in the study; however, this would have proven difficult as most ROTC programs do not employ athletic trainers and there is not a unified injury recording and surveillance system used by ROTC Cadet Command.

CHAPTER V: CONCLUSION

To the authors' knowledge this is the first study to explore the effects of an injury prevention course on injury incidence in a military population as the sole intervention. The results of this study failed to show a significant decrease in the number of injuries that occurred in ROTC cadets after an injury prevention class when compared to a previous semester. An unexpected result occurred in the form of a shift from primarily cumulative to primarily acute traumatic injuries after the class; although, the data gathered in this investigation could not provide potential explanations for such a change. Classroom instruction alone may not be a productive injury prevention initiative, but it remains an essential component of overall prevention efforts. Further research is necessary to determine how best to educate and change the attitudes and behaviors of at-risk populations when attempting to implement interventions for musculoskeletal injuries.

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TABLES

Table 1. Cadet Demographic Information

Anthropometry and APFT Scores	Fall 2017		Fall 2018	
	Female	Male	Female	Male
Height (in.)	65 ± 3	70 ± 2	64.5 ± 3	70 ± 3
Weight (lbs.)	137 ± 19.5	173 ± 20.5	135 ± 17	175 ± 23.5
Age (yr.)	19 ± 1	20 ± 2	20 ± 1	20 ± 2
APFT				
Push Ups	41 ± 9	72 ± 13	45 ± 10	70 ± 15
Sit Ups	66 ± 13	73 ± 10	74 ± 16	71 ± 15
2-mile Run (min:sec)	17:56 ± 1:24	14:13 ± 1:18	16:45 ± 1:01	14:23 ± 2:39
Score	242 ± 36	264 ± 32	269 ± 34	258 ± 51

Table 2. Distribution by Percentage of Cadets' Beliefs on Musculoskeletal Injury Risks and Interventions Prior to Injury Prevention Course

Factors that:	Response Percentage			
Increase Risk of Injury*	Decrease Risk	Neither Increase nor Decrease	**Increase Risk***	Not Sure
Increased Running Mileage	15%	25%	48%	12%
Dehydration	4%	0%	94%	2%
Prior Injury	4%	0%	94%	2%
Cigarette Smoking	0%	2%	96%	2%
High Flexibility	78%	8%	10%	4%
Very Thin Body Type	4%	22%	67%	8%
Low Physical Fitness Level	6%	6%	86%	2%
Low Caloric Intake	10%	6%	80%	4%
Does Not Decrease or May Increase Risk*	Decrease Risk	**Neither Increase nor Decrease***	**Increase Risk***	Not Sure
Back Brace/Lifting Belt	65%	6%	16%	12%
NSAIDs Before Exercise	29%	24%	33%	14%
NSAIDS After Exercise	45%	22%	18%	8%
Stretching Before Exercise	90%	2%	8%	0%
Reduce Risk of Injury*	**Decrease Risk***	Neither Increase nor Decrease	Increase Risk	Not Sure
Ankle Brace	59%	6%	20%	16%
Synthetic Socks	55%	22%	16%	8%
Agility / Balance Training	42%	12%	40%	6%
Mouth Guards	69%	18%	4%	10%
Helmets	84%	2%	4%	10%

Does Not Decrease nor Increase Risk	Decrease Risk	**Neither Increase nor Decrease***	Increase Risk	Not Sure
Minimalist Running Shoes	19%	8%	65%	8%
Stretching After Exercise	94%	2%	4%	0%
Effect on Risk not Evident / Is Variable*	Decrease Risk	Neither Increase nor Decrease	Increase Risk	**Not Sure***
Fatigue	4%	2%	88%	6%
Lack of Sleep	4%	0%	92%	4%
High Body Mass Index	10%	6%	75%	8%
Proper Exercise Technique	90%	0%	4%	6%
Older Age (>40 years)	0%	6%	80%	14%
Male Sex	27%	37%	18%	18%
Dietary Supplements	27%	20%	37%	16%
Older Running Shoes	12%	8%	79%	2%
*Current assessment of scientific evidence in military populations based on recommendations from the Work Group				

Table 3. Distribution by Percentage of Cadets' Beliefs on Musculoskeletal Injury Risks and Interventions After Injury Prevention Course

Factors that:	Response Percentage			
Increase Risk of Injury*	Decrease Risk	Neither Increase nor Decrease	**Increase Risk***	Not Sure
Increased Running Mileage	2%	2%	96%	0%
Dehydration	0%	2%	98%	0%
Prior Injury	0%	2%	98%	0%
Cigarette Smoking	0%	2%	98%	0%
High Flexibility	15%	13%	73%	0%
Low Physical Fitness Level	7%	2%	91%	0%
Very Thin Body Type	0%	5%	95%	0%
Does Not Decrease or May Increase Risk*	Decrease Risk	**Neither Increase nor Decrease***	**Increase Risk***	Not Sure
Back Brace/Lifting Belt	13%	15%	70%	9%
NSAIDs Before Exercise	8%	14%	76%	2%
NSAIDS After Exercise	15%	31%	52%	2%
Stretching Before Exercise	10%	44%	46%	0%
Low Caloric Intake	2%	0%	98%	0%
Reduce Risk of Injury*	**Decrease Risk***	Neither Increase nor Decrease	Increase Risk	Not Sure
Ankle Brace	80%	7%	13%	0%
Synthetic Socks	89%	2%	9%	0%
Agility Training	62%	10%	26%	2%
Mouth Guards	89%	2%	7%	2%
Helmets	91%	0%	4%	0%

Does Not Decrease nor Increase Risk	Decrease Risk	**Neither Increase nor Decrease***	Increase Risk	Not Sure
Minimalist Running Shoes	16%	16%	64%	4%
Stretching After Exercise	46%	38%	17%	0%
Effect on Risk not Evident / Is Variable*	Decrease Risk	Neither Increase nor Decrease	Increase Risk	**Not Sure***
Fatigue	7%	2%	91%	0%
Lack of Sleep	2%	2%	95%	0%
High Body Mass Index	2%	7%	89%	2%
Proper Exercise Technique	84%	2%	10%	2%
Older Age (>40 years)	9%	13%	78%	0%
Male Sex	33%	38%	27%	2%
Dietary Supplements	17%	10%	71%	2%
Older Running Shoes	2%	6%	90%	2%

*Current assessment of scientific evidence based on recommendations from the Work Group

Area where further education may be warranted based on ≥10% answers not aligning with course content or scientific literature

Key concern based on ≥30% answers not aligning with course content or scientific literature

Table 4. Breakdown of Cadet Injuries by Semester, Body Region, Sex, and Mechanism

Fall 2017			Fall 2018	
by Body Region			by Body Region	
Foot	1		Ankle	2
Ankle	1		Lower Leg	6
Lower Leg	4		Thigh	2
Knee	4		Lumbar Spine	2
Thigh	2		Cervical Spine	1
Hip	2		Shoulder	1
Lumbar Spine	2		Elbow	1
by Sex			by Sex	
Male	7		Male	11
Female	9		Female	4
by Mechanism			by Mechanism	
Acute	5		Acute	11
Cumulative	11		Cumulative	4
Total	16		Total	15

FIGURES

Figure 1. Percentage of Correct Responses on Pre- and Post-Course Quizzes

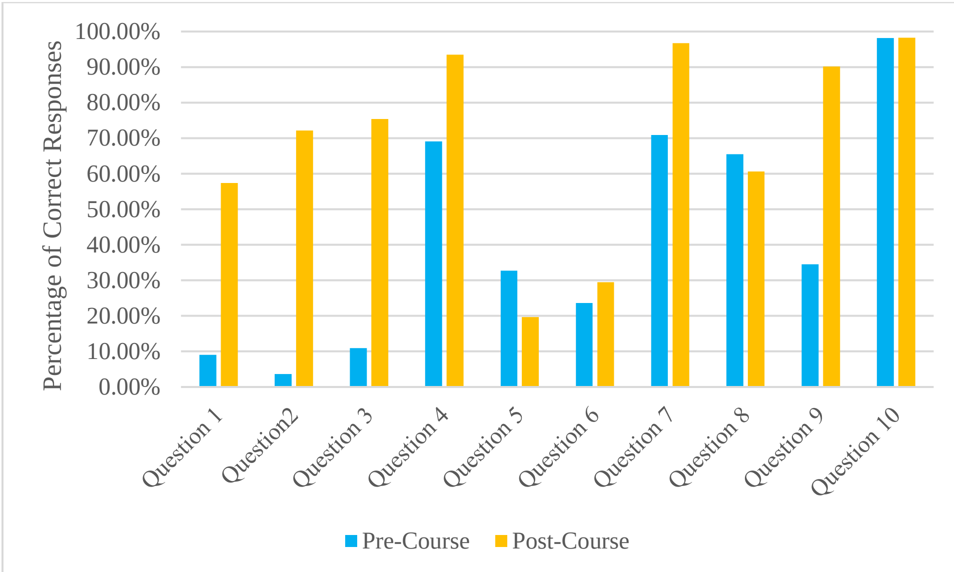


Figure 2. Cadet Self-rated Aerobic Endurance

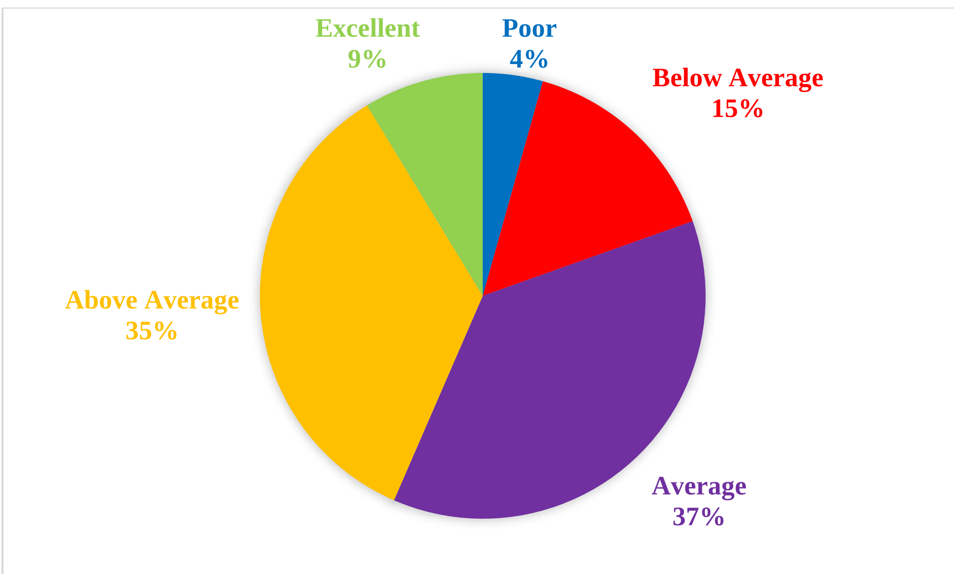


Figure 3. Cadet Self-rated Muscular Strength

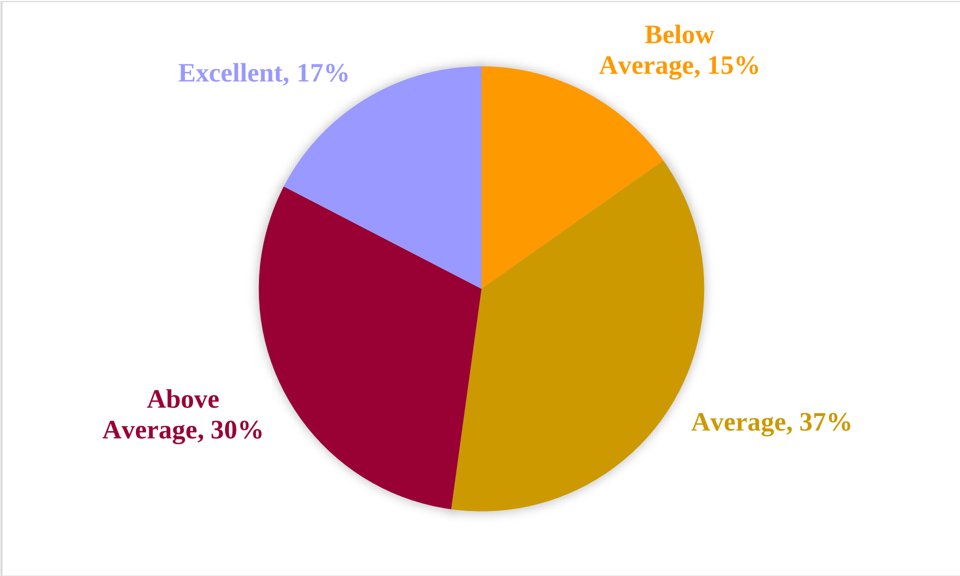


Figure 4. Injury Mechanisms Reported on Pre-class Survey

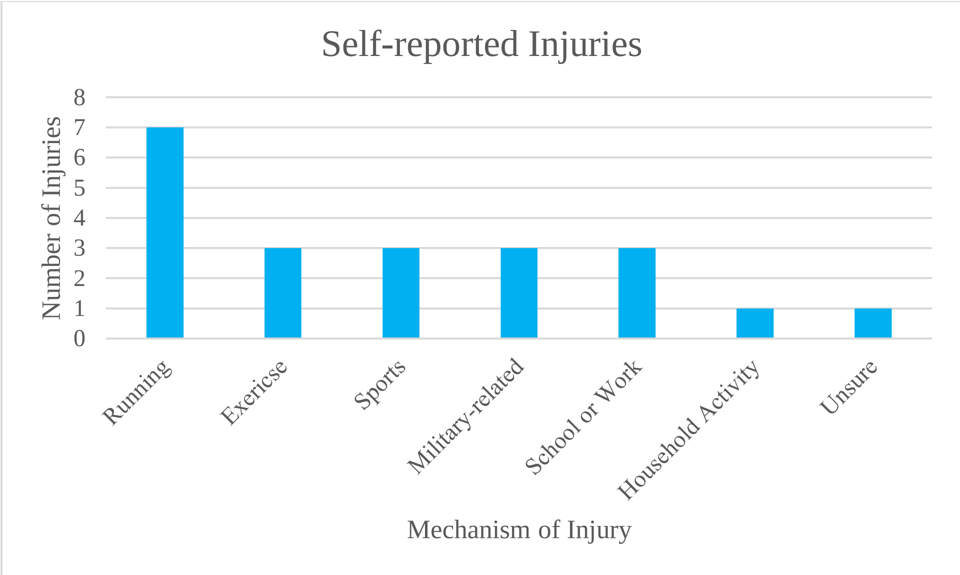


Figure 5. Cadet Beliefs on Major Injury Mechanisms in the U.S. Army

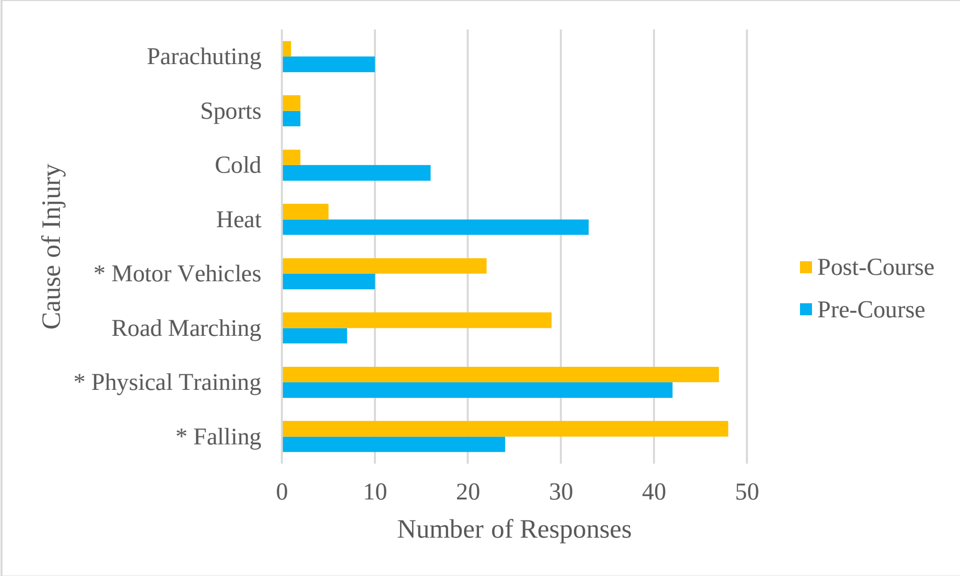


Figure 6. Cadet Responses to the Statement: "Injuries represent the biggest threat to the Army's readiness to fight."

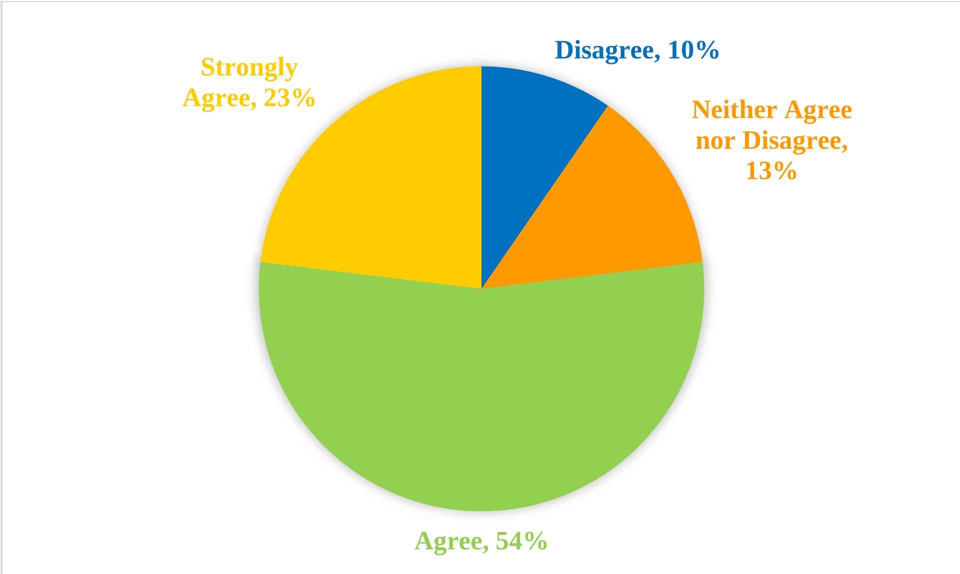


Figure 7. Cadet Responses to the Statement: "Muscle/joint/tendon/ligament/bone injuries resulting from overuse are a bigger problem to the Army than those injuries from single incidents/accidents."

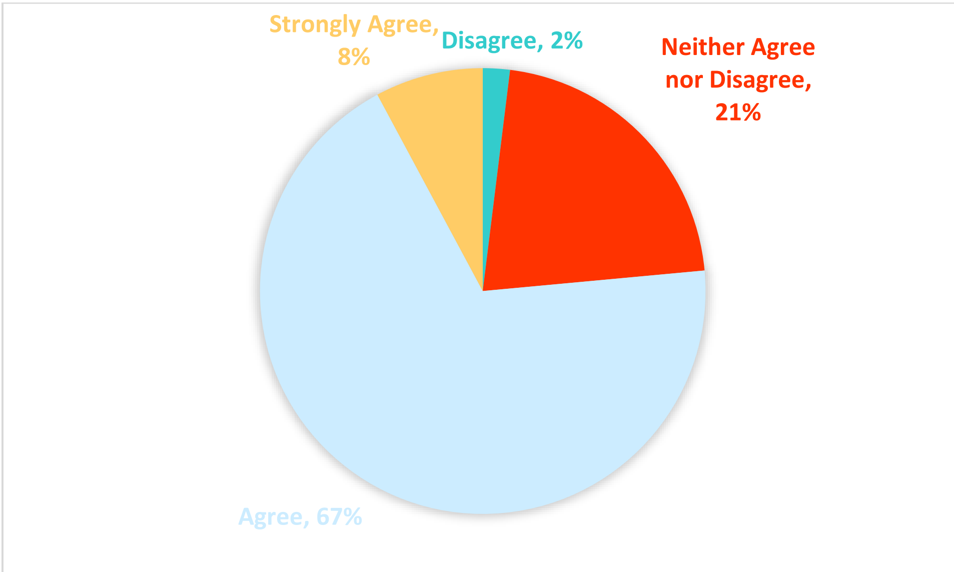


Figure 8. Cadet Perceptions of Leadership Opinions

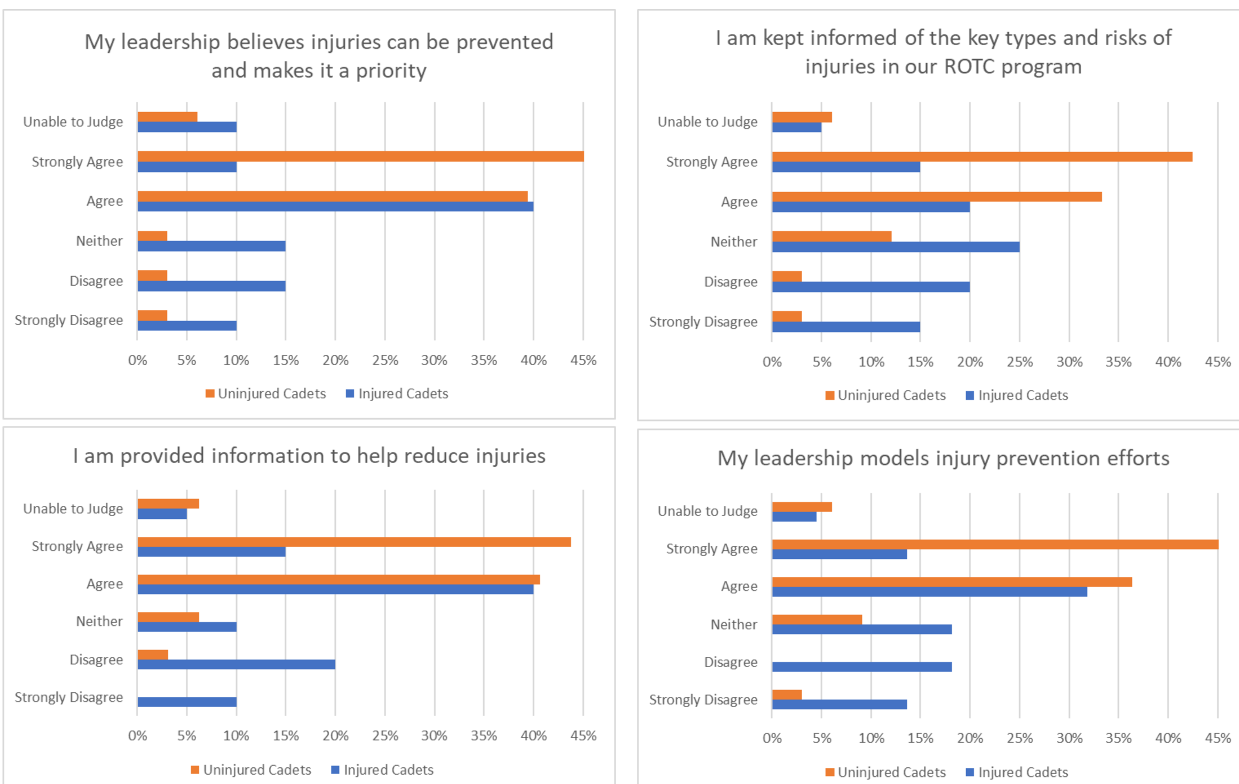


Figure 9. Areas of Cadet Interest for Further Injury Prevention Information

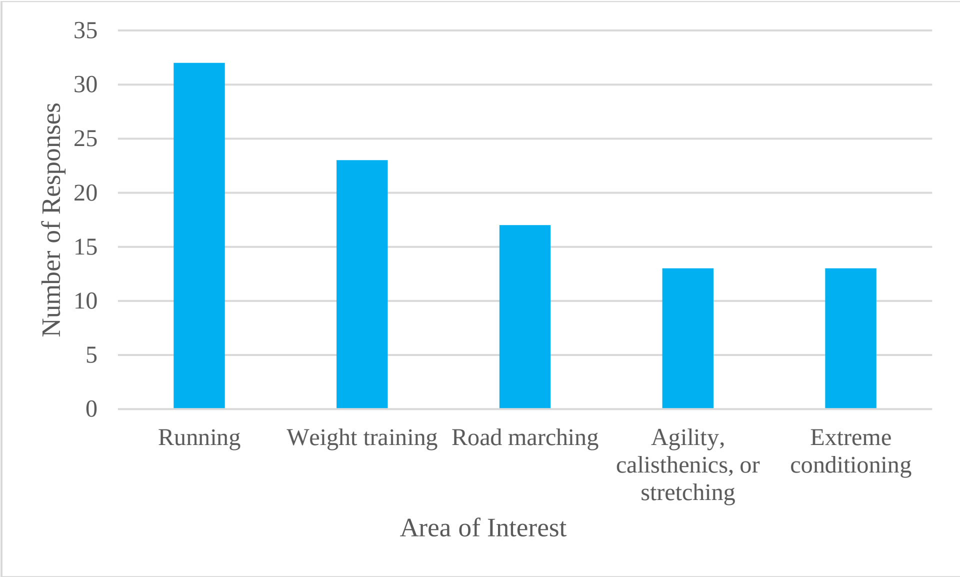
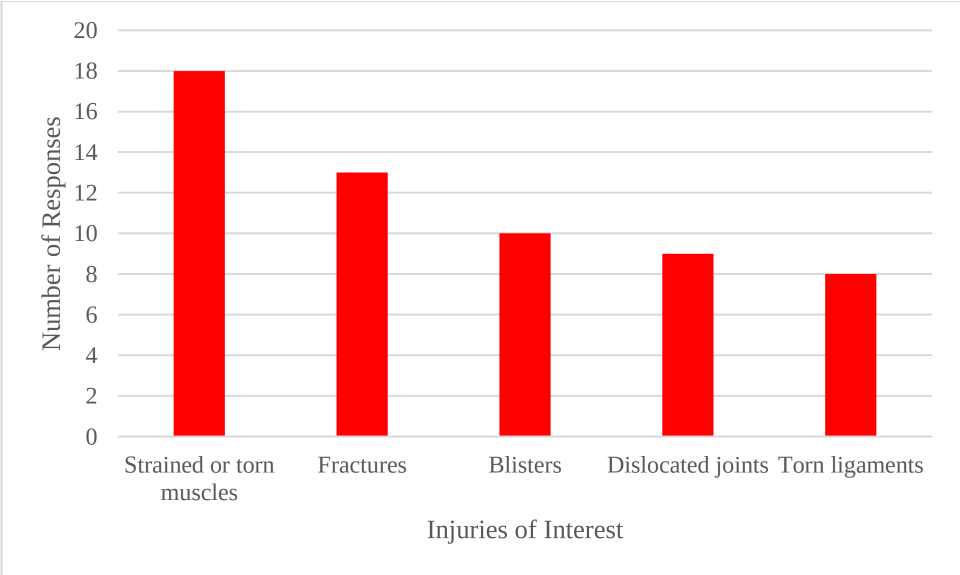


Figure 10. Injuries for which Cadets Desired to Learn More



APPENDIX A: INJURY PREVENTION SURVEY

The following questions were reproduced from *Injury Prevention Survey: Army Awareness Assessment and Needs Analysis* with permission from Veronique Hauschild, MPH of the U.S. Army Public Health Center. Questions were modified to reflect the ROTC cadet population rather than soldiers currently in the Army. Some questions were omitted due to relevance. The full survey in its original form may be found in APHC Public Health Report No. S.0023151.

Pre-course Survey

The following survey was completed by participants prior to the injury prevention education course.

How would you rate the following elements of your physical fitness compared to others of your same age and gender?

	Poor	Below Average	Average	Above Average	Excellent
Stamina/Aerobic Endurance	O	O	O	O	O
Muscle Strength	O	O	O	O	O

In the last 12 months, did you sustain an injury involving your muscles, bones, tendons, ligaments, or joints that affected your physical ability to do daily tasks or exercise?

- ○ *Yes*
- ○ *No*
- ➢ *The most severe injury you had in the last 12 months was primarily the result of:*

- *A single incident/accident such as from lifting an object, falling or tripping, an automobile accident*
- *Overuse resulting from repetitive movement of body parts (e.g., strained muscles, ligaments, tendons, joints, or stress fractures)*
- *Not sure*

➢ *The most severe injury you had in the last 12 months was primarily due to:*

- *School or work-related activity – slipping/tripping/falling*
- *School or work-related activity – lifting/pulling/pushing*
- *Military-related – road marching*
- *Military-related – combat training drills*
- *Military-related – obstacle course*
- *Exercising – running*
- *Exercising – Activity other than running (please specify)*
- *Sports (please specify)*
- *Motor vehicle*
- *Household activity*
- *Other (please specify)*
- *Not sure*

Injuries represent the biggest threat to the Army's readiness to fight.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Muscle/joint/tendon/ligament/bone injuries resulting from overuse are a bigger problem to the Army than those injuries from single incidents/accidents.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Preventable non-combat injuries were the leading reason for air medical evacuation during deployments to Iraq and Afghanistan.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

The 3 most common muscle/joint/tendon/ligament/bone injuries experienced by military personnel are to the back, knees, and ankles.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

What do you think are the 3 leading causes of physical injuries in Active Duty Army personnel? (Select 3)

- ☐ *Cold*
- ☐ *Falling/tripping*
- ☐ *Heat*

- ☐ *Motor vehicles*
- ☐ *Parachuting*
- ☐ *Physical training (e.g., running, resistance training, agility training, etc.)*
- ☐ *Road marching*
- ☐ *Sports (e.g., basketball, football, soccer, racquetball, etc.)*
- ☐ *Other (please specify)*

Check how you think each of the following impact a person's risk of injury to muscles/tendons/ligaments/joints/bones:

Factor/Activity	DECREASES Risk of Injury	INCREASES Risk of Injury	NEITHER Decreases nor Increases Risk of Injury	NOT SURE
Increased running mileage	O	O	O	O
Minimalist running shoes	O	O	O	O
Older running shoes	O	O	O	O
Stretching before exercise	O	O	O	O
Stretching after exercise	O	O	O	O
High flexibility	O	O	O	O
Agility training (quick changes of direction)	O	O	O	O
Over-the-counter anti-inflammatory or pain medications BEFORE workouts (such as ibuprofen, naproxen, or acetaminophen)	O	O	O	O
Over-the-counter anti-inflammatory or pain medications AFTER workouts	O	O	O	O

Back-brace/lift belt (for job or weight training)	O	O	O	O
Ankle brace	O	O	O	O
Mouth guards	O	O	O	O
Helmets (motorcycles, bicycles)	O	O	O	O
Proper technique (running, weight lifting, stretching, calisthenics)	O	O	O	O
Moisture wicking (synthetic/non-cotton) socks	O	O	O	O
Cigarette smoking	O	O	O	O
Older age (>40)	O	O	O	O
Male sex	O	O	O	O
Low physical fitness level	O	O	O	O
High Body Mass Index	O	O	O	O
Very thin body type	O	O	O	O
Dehydration	O	O	O	O
Prior Injury	O	O	O	O

Factor/Activity	DECREASES Risk of Injury	INCREASES Risk of Injury	NEITHER Decreases nor Increases Risk of Injury	NOT SURE
Fatigue	O	O	O	O
Lack of sleep	O	O	O	O
Energy or dietary supplements	O	O	O	O
Low calorie intake	O	O	O	O

To what extent do you agree or disagree with each of the following statements about those individuals in your chain of command, starting with your squad leader?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A, unable to assess my leadership in this area
My leadership believes injuries can be prevented and makes it a priority	O	O	O	O	O	O
I am kept informed about the key types and risks of injuries in our ROTC program	O	O	O	O	O	O

I am provided information to help reduce injuries (my own and/or others)	O	O	O	O	O	O
My leadership models injury prevention efforts	O	O	O	O	O	O

Post-course Survey

Participants completed a second survey after completion of the course. The second survey included all questions from the first survey except the first two series of questions and the last series. The second survey also included the following items.

Check the activities about which would be interested in obtaining more injury prevention information:

- ☐ *Running*
- ☐ *Agility, calisthenics, stretching*
- ☐ *Extreme conditioning (e.g., CrossFit)*
- ☐ *Weight training*
- ☐ *Road marching injury prevention*
- ☐ *Other (please specify)*

What injuries are you most interested in learning about?

- ☐ *Abrasion or lacerations*
- ☐ *Blisters*
- ☐ *Dislocated joints*

- ☐ *Fracture (stress fractures and broken bones)*
- ☐ *Sprained or torn muscles*
- ☐ *Tendonitis or bursitis*
- ☐ *Torn ligaments*
- ☐ *Other (please specify)*

How would you like to obtain injury prevention information?

- ☐ *Computer*
- ☐ *Mobile device*
- ☐ *Printed material*
- ☐ *Other (please specify)*

What types of injury prevention information or educational materials would you prefer?

- ☐ *Brochures*
- ☐ *Posters*
- ☐ *Factsheets*
- ☐ *Technical reports or articles*
- ☐ *Other (please specify)*

If you have any other comments you wish to share, you may write any response in the space below.

APPENDIX B: COURSE CONTENT QUIZ

Please complete the following questions to the best of your ability.

1. Which of the following is most responsible for running-related injuries?

   A. Frequency   C. Duration

   B. Mileage   D. Speed

2. Stretching prior to exercise has been shown to decrease injury rates.

   A. True   B. False

3. __________ is the leading cause of hospitalizations in the Army.

   A. Car accidents   C. Falls

   B. Physical training   D. Combat

4. Synthetic blend socks help prevent blister formation.

   A. True   B. False

5. When adjusted for time, __________ leads to the most injuries.

   A. Confidence courses   C. Resistance training

   B. Ruck marching   D. Running

6. Which drill focuses on lower extremity strength and plyometrics?

   A. CD2   C. CL2

   B. HSD   D. CD3

7. The majority of disability discharges are due to physical training.

   A. True   B. False

8. __________ is the greatest predictor of injury in the Army.

   A. Sex   C. Body weight

B. Fitness D. Age

9. Which is not recommended for injury prevention?

A. Back braces C. Ankle braces

B. Appropriate nutrition D. Mouth guards

10. Many training injuries are preventable through activity modification.

A. True B. False