RISK FACTORS FOR MUSCULOSKELETAL INJURIES IN DEPLOYED FEMALE SOLDIERS

by

Tanja C. Roy

Bachelors of Art, University of Notre Dame, 2000

Masters of Physical Therapy, Baylor University, 2002

Doctorate of Physical Therapy, Baylor University, 2007

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SCHOOL OF HEALTH AND REHABILITATION SCIENCES

This dissertation was presented

by

Tanja C. Roy

It was defended on

May 29, 2014

and approved by

James Irrgang, PhD, PT, ATC, Associate Professor, Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

Charity Moore, PhD, Associate Professor, School of Medicine, University of Pittsburgh

Anthony Delitto, PhD, PT FAPTA, Professor and Associate Dean of Research, Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

Teresa Brininger, PhD, Lieutenant Colonel, U.S. Army

Dissertation Advisor: Sara R. Piva, PhD, PT, FAPTA, Associate Professor, Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

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Tanja C. Roy, PhD, DPT, SCS

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Each year musculoskeletal injuries (MSI) result in thousands of lost duty days per unit as well as thousands of medical discharges resulting in billions of dollars in disability costs. Approximately 15% of the U.S. Army is made up of women and no studies have identified risk factors for MSIs while deployed despite the fact that female soldiers have higher incidence rates of MSIs than male soldiers. The purpose of this prospective cohort study was to investigate occupational, physical, and psychosocial risk factors for musculoskeletal injury in female soldiers.

Female participants were recruited from three Brigade Combat Teams deploying during 2012. They underwent performance testing and completed surveys on demographics, sleep, coping, and job stress prior to deployment. Upon completion of the deployment, soldiers completed the surveys again plus an additional survey on occupational demands and MIs.

Of the 160 women, 57 (36%) suffered 78 resulting in 1642 days of limited duty. Most injuries were to the knee (24%) or low back (18%). Soldiers identified physical training as the self-reported cause for most injuries (27%). In univariate analysis, injured soldiers had significantly higher average load worn and more time wearing it; higher heaviest load worn and more time wearing it; more time spent wearing body armor or a back pack; higher average weight of lifted objects, more repetitions of lifting it, and carrying it further; higher Y Balance composite score; and more family members. In multivariate analysis of physical and occupational variables, the average load and heaviest load worn, the average number of times an

object was lifted, and the number of sit ups performed were predictors of MSI. None of the psychosocial variables predicted MSI. In the combined multivariate model, the most parsimonious set of risk factors was, average load worn (OR=1.04), heaviest load worn (OR=1.03), average number of times an object was lifted (OR=1.07), and number of sit ups performed on the Army Physical Fitness Test (OR=0.96).

These results suggest that injury prevention programs designed to improve load bearing ability, lifting endurance, and core strength should be considered to decrease MSIs in deployed female soldiers.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

With conflicts in both Iraq and Afghanistan occurring simultaneously, U.S. Army soldiers are spending more time deployed to combat zones. Over two million service members (Army, Navy, Marines, and Air Force) have deployed in the last ten years for 6-15 months with 40% of service members deploying more than once.[1] This increased operational tempo has resulted in an unknown change in physical demands on the soldier which in turn can affect the risk of injury.[2] In fact, musculoskeletal injuries (MSIs) account for at least twice as many medical evacuations as combat injuries.[3-5] They are also the leading cause of ambulatory medical visits, both in the U.S. and while deployed to combat zones.[6-10] MSIs are very costly in lost duty days, medical care expenses, evacuations, and medical discharges from military service. Furthermore they reduce manpower and combat strength, decrease morale, and threaten overall mission accomplishment. The studies investigating MSIs in deployed environments to date have been made up of at least 80% men with no sub set analysis performed on female soldiers.[2,9,11,12] Studies have shown that the burden of injuries is greater in female soldiers than male soldiers.[13-15] Risk factors for MSIs are different in men than women studied in the U.S. therefore studies that identify risk factors for MSIs in deployed female soldiers are warranted.[14,16] This study proposes to study risk factors for MSIs in female soldiers deployed to Afghanistan. By identifying risk factors for MSIs in women, effective injury prevention programs can be developed to reduce MSIs and consequently decrease medical costs and discharges and increase manpower and morale.

1.1 MUSCULOSKELETAL INJURY INCIDENCE

1.1.1 Musculoskeletal Injury Incidence in Deployed Soldiers

Musculoskeletal injury incidence rates vary across studies on deployed populations. In a survey study of over 3,000 deployed military service members by Skeehan et al.[12], 19.5% reported at least one musculoskeletal injury and 39% of those reported more than one injury. In a second study of over 15,000 deployed service members by Sanders et al.[9], 35% reported a MSI, 77% of those sought medical care. A third study by Konitzer et al.[2] reported a 70% injury rate for neck, back and upper extremity injury. Finally, a fourth study done in Iraq found an incidence rate of 16%.[11] It is possible that the injury rate found by Konitzer et al.[2] was higher because injury was defined simply as pain. However, the definition of injury is not listed in the articles by Sanders et al.[9] or Skeehan et al.[12] Belmont et al.[11] used an electronic records review in order to assess injury and this is possibly the reason for finding a low incidence rate. At this time, electronic records capability was only available on the few very large bases and would not account for any injuries sustained by soldiers on the majority of bases. In our own pilot data, 61.4% of women were injured and 43.9% of men. Sanders, and Skeehan did not conduct subset analysis on injury by gender. The lower rates of 19.5% and 35% include both men and women and are male dominated, at least 80% male. It is likely that the high proportion of men in the sample resulted in a lower overall injury rate than if the injury rate in female soldiers was calculated separately. MSIs are clearly a common problem in deployed soldiers.

Most previous studies on MSIs in combat zones categorize injuries by anatomical region affected. In the study of over 15,000 service members by Sanders et al.[9] the most commonly injured body regions were the low back (24%), followed by hand/fingers (23%), ankle/foot (22%), knee (18%), and shoulders (12%).[9] Similar results can be seen in the study by Konitzer et al.,[2] where 60% reported back pain, 40% upper extremity pain, 30% reported neck pain. Regardless of the theatre of operation, the low back is the most commonly injured anatomical region.[9,17,18] Low back pain is much more prevalent while deployed (21.2% in Afghanistan, 26.9% in Bosnia, and 23.2% in Iraq) compared to 17.8% (includes back and abdomen) of non-deployed military members.[17-19] Additionally, low back pain is the leading cause for medical evacuation from combat zones.[4] Roy was the only study to investigate diagnosis in addition to body region injured of the deployed injury studies.[20] The most common diagnoses treated by the physical therapist in Afghanistan were mechanical low back pain (19%), ankle sprain (12%), and patellofemoral pain syndrome (4%).[20]

1.1.2 Musculoskeletal Injury Incidence in Women

All studies done on service members in the U.S. have found that women have a higher incidence rate of MSIs than men. Studies in basic training populations have shown that 45% to 57% women sustain a MSI whereas only 27% to 46% of men.[13-15] The crude injury rates indicate that women can be up to twice as likely as men to suffer a MSI.[13] While MSIs are an issue in non-deployed environments, they have an even greater diminishing effect on U.S. military strength in combat zones and the effect on female soldiers is largely unknown. Women make up 10-15% of U.S. Army and suffer more MSIs than men.[11,14,21,22] When compared to all other health problems, MSIs cause the greatest reduction in combat readiness.[23] Female soldiers are impacted more than men, yet studies on MSIs during deployment have all been made up of at least 80% men.[23]

Research studies conducted on military populations in non-deployed settings have shown that not only is the overall injury incidence rate different between men and women but the injuries themselves are different. [15,24] In a study of 1,210 service members, women suffered ankle, upper extremity, and lower leg injuries the most, whereas men sustained a majority of ankle, back, and lower leg injuries.[24] The top five diagnoses in female officer recruits were ankle sprain, sprain of the arm/hand/shoulder, shin splints/lower leg, back/neck sprain, and knee sprain; whereas for men it was ankle sprain, back/neck sprain, shin splints/lower leg, knee tendonitis, and hip strain.[24] In a second study, men had more ankle/foot injuries than women. [28] In a third study that investigated lower extremity injuries, women had predominately patellofemoral pain syndrome, ankle sprains, and iliotibial band syndrome; whereas men suffered similar injuries but in a different order of frequency: iliotibial band syndrome, ankle sprain, and Achilles tendonitis.[15] In a fourth study of basic trainees, the injuries most suffered by male soldiers were low back pain, tendonitis, sprains, strains, and stress fractures, and for women it was strains, stress fractures, sprains, tendonitis, and knee pain.[14]

1.1.3 The Burden of Musculoskeletal Injuries in the U.S. Army

The large numbers of soldiers suffering MSIs can lead to a reduction in work efficiency, decrease in combat strength, and an increase in medical discharges from the U.S. Army. The number of lost duty days from MSIs is higher than that of illness.[22,24,25] The average musculoskeletal injury can cause up to 16 days of limited duty, ten times the number of limited duty days due to illness.[25] Skeehan et al. found that 36% of the 3,367 surveyed service members were given limited duty for an average of six days due to MSIs.[12] In the records review by Rhon, 10% of the physical therapy patients received limitations to duty lasting an average of 18 days.[19] The profile rate (limited duty rate) for women due to musculoskeletal injury can be significantly higher than men, 2.66% in women compared to 1.80% in men in the U.S.[26] During mechanic advanced individual training, 41% of men and 51% of women received limited duty for injury.[27] Overuse injuries resulted in 80% of lost duty time in women in Marine Officer Basic.[28] Sprains caused the highest number of lost duty time in women but for men it was stress fractures in the U.S.[28] MSIs are reducing the work force stationed in the U.S. and having the greatest impact on women. Up to 60% of soldiers suffering injuries are unable to return to full duty immediately while stationed in the U.S., 10% while deployed to Iraq, and 20% while deployed to Bosnia and Afghanistan.[18-20,29] MSIs accounted for the most lost duty days during Desert Shield as well.[8]

Compared to all other health problems MSIs cause the greatest reduction in combat readiness.[23] Skeehan et al. found 42% of survey service members had difficulty performing their duties due to injury and 19% of those injured could not perform their job at all and had to be replaced by other personnel.[12] Decreased job performance was more often reported for injuries due to gear/lifting than sports/athletics.[12] Five percent of injured soldiers missed a patrol due to injury.[12] In a separate study, 21% of injured soldiers stated they had difficulty firing their weapon.[2] In a study by Sanders et al. 17% of 15,000 service members were unable to completely do their jobs due to injury.[9] Twenty-five percent of soldiers believed unit effectiveness had been negatively affected by injury.[9] MSIs are clearly having a negative effect on our service members' ability to perform their occupational tasks especially in combat environments. Women lose more duty time from injury than men in studies conducted in non-deployed areas, but this has not been assessed in deployed environments and both studies above combined men and women during their analysis. Research is needed to support the creation of injury prevention methods in order to reduce the lost man hours due to injury especially in women.

1.1.4 Military Discharge and Economic Burden of Musculoskeletal Injuries in the U.S. Army

Beyond having a temporary effect on some soldiers' ability to work, MSIs can have a permanent effect as well. The medical discharge rate for the U.S. Army has increased seven fold in the last 20 years.[30] This rise is driven by an increase in discharges due to MSIs, especially those in women.[30,31] Musculoskeletal medical discharges in women have increased 8% a year compared to 5% for men and increased over 30 fold for women and over 17 fold for men from 1981 to 2005.[30] Twenty-nine billion dollars were spent on medical discharge payments in 2005, most of which were a result of MSIs.[30] These figures do not include the cost of training replacements for permanently injured soldiers. MSIs result in a large increase in medical discharges in women. The proposed study will investigate risk factors for these injuries. Once the risk factors are identified, modifiable risk factors can be addressed using rehabilitation type training programs in order to reduce the incidence of injury and the subsequent medical discharges with potential savings in the billions of dollars.

1.1.5 Significance of Studying Risk Factors of Musculoskeletal Injuries in Female Soldiers

No study on MSIs in deployed environment has focused on women despite the fact that women are more susceptible to MSIs than men.[13-15] Women suffer different MSIs than men as discussed above. With the type of injury differing between the sexes, it is likely that risk factors differ between the sexes as well. The proposed study will investigate risk factors for MSIs in women deployed to Afghanistan. No previous deployment studies have separated men from women in their analysis despite evidence from U.S. studies showing that the injuries are different in men and women. Women make up 10-15% of the U.S Army and they have an injury incidence rate of approximately 50% while deployed, which means that 5-7.5% of the force will be injured and therefore not able to work at full capacity.[11] This study will identify risk factors for injury in women. Risk factors specific to the injuries for women need to be identified in order to create rehabilitation prevention programs that will reduce injuries in women, thereby allowing them to continue to work at full capacity. If prevention strategies are designed based off the injuries in men, they will likely not be as effective in women, missing the mark on 10-15% of the Army population.

1.2 POTENTIAL RISK FACTORS FOR MUSCULOSKELETAL INJURIES

Modifiable risk factors must be identified for these injuries in order to reduce injuries. To create a successful injury prevention program, surveillance of the injuries must be completed followed by identification of risk factors. Once modifiable risk factors have been identified, rehabilitation type training programs to prevent MSIs can be created and implemented. An example of preventive program development from identification of risk factors in the military is the change in physical fitness training. Injury surveillance noted that there were a large number of MSIs during physical training.[25,27,32-34] Further investigation discovered that running mileage was a risk factor for these MSIs.[35-37] The military then began implementing a new program to decrease the running mileage while maintaining the training volume and intensity by substituting exercises with less impact.[35] Successful implementation of this program resulted in a 21% decrease in MSIs with no loss of fitness.

To date, despite injury rates of MSIs in deployed environments ranging from 20% to 70%, few studies have investigated risk factors for MSIs in deployed environments.[2,9,11,12] Prior studies on risk factors during deployment have studied limited occupational risk factors, body armor wear, heavy loads, vehicle accidents and demographic risk factors such as age, rank, unit type, and prior deployment.[2,9,12] Occupational risk factors have only been sparsely studied in deployed environments despite leading to many MSIs. Physical risk factors such as fitness and psychosocial risk factors do not appear to have been studied at all. The proposed study will further investigate occupational, physical, and psychosocial risk factors for women while deployed to Afghanistan. Prevention strategies targeting the risk factors for injuries in deployed women would then reduce the current 50% injury rate decreasing medical costs and medical discharges, and increasing the available manpower.[11]

1.2.1 Occupational Risk Factors

In pilot data collected from the 5th Stryker Brigade while in Afghanistan from 2009-10, 95% of injuries (of injuries which included a report of cause) occurred during occupational activities. Occupational tasks are the leading cause of injury and are different in men and women. British female soldiers suffered back injuries from physical training, occupational tasks, and off duty activities such as sports at a significantly greater rate than men.[38] Physical training, mechanical work, airborne activity, road marching, and garrison activities were the leading causes of injury in women; while physical training, mechanical work, sports, and airborne activity were the leading causes in men.[27] In many Military Occupational Specialties (MOS)(such as wheeled vehicle mechanic, signal intelligence analyst, and voice interceptor) women were had significantly more medical discharges than men.[31] Some aspect of these occupations is causing an increase in disabling medical conditions in women compared to men. Many soldiers in specific MOSs often perform tasks unrelated to their MOS. Their primary duty tasks are often more related to injury than the actual MOS. Within these primary duties, it is important to identify what tasks within occupations are leading to injury in women. Simply identifying occupations as a risk factor is not enough. The proposed study will improve upon current knowledge by identifying modifiable risk factors within the framework of occupations such as primary occupation, load carriage, lifting and weight bearing activities. These risk factors can then be changed or programs can be created to make a soldier less susceptible to injury from identified risk factors.

1.2.1.1 Primary Occupation

Soldiers are trained in specific MOSs, occupations. However, soldiers do not always perform these MOS as their primary duty when they are deployed. For example, cooks may not cook but work as guards. Rather than look at specific MOSs, the proposed study will investigate the primary duty performed by each soldier. We will record what soldiers do each day, not which job they were originally trained for but are perhaps not performing. Skeehan et al.[12] divided subgroups by unit type; ground forces, support units, command units, and special operation units. They found an increased risk of MSI for ground forces (relative risk ratio (RR) of 1.8), support units (RR=1.7), and special operations units (RR=1.9) compared to command units. In theory, soldiers in ground units and special operations units perform more physical activity than other units. They likely perform more load carriage but less lifting than support units. One flaw with this method of categorizing soldiers is that within a unit soldiers have many different occupations. Different units also perform the same primary job. For example, soldiers in both ground forces and support units conduct convoy operations. In the proposed study we will record primary duty for each female soldier. By investigating the primary duty instead of the unit assigned in addition to recording her MOS, will provide a more accurate description of occupations and what tasks within each occupation are leading to MSI. Prevention methods such as increased pre-deployment physical training for specific duties, if identified as risk factors, can then be created and implemented.

1.2.1.2 Load Carriage

Within occupational tasks load carriage (wearing heavy equipment) has been identified by soldiers as a cause of injury.[2,9] The military has continued to increase the load carried by soldiers over the years. In World War I soldiers were asked to carry 27 kg packs.[39] In 2003 the weight carried by the average infantry man in Afghanistan was 44 kg.[40] Several recent studies have looked at the effects of these ruck sack loads on soldiers. Special Forces soldiers carried loads of 34, 48, and 61 kg for 20 km with at least three days between trials. Soldiers complained of no back discomfort with the 34 kg pack but did complain of discomfort at the completion of marching with both the 48 kg and 61 kg packs. Soldiers complained of 18% more back discomfort with the 61 kg pack than with the 48 kg pack.[41] The post-march difference in pain, soreness, and discomfort scores were significantly higher with heavier packs.[42] In a separate study, after completing a 20 km road march with 46 kg, soldiers suffered an 82% increase in fatigue and a 38% decrease in vigor.[43] These soldiers reported 2.6 out of 6 pain level in the low back at completion of the march. In another study, soldiers conducted a standard 20 km road march carrying loads of 46 kg to include uniform and helmet.[44] Six percent of the unit suffered from back pain during or after the road march.[44] As the packs get heavier the soldiers slow down and have more pain and injury. Heavy loads have also been shown to have a negative effect on soldiers in combat studies as well as in the previously mentioned laboratory based studies. Heavy gear/lifting was identified as the second most frequent cause of MSIs in the study by Skeehan et al.[12] Sanders et al. found similar results with heavy loads leading to 14% of injuries.[9] Of 863 surveyed soldiers by Konitzer et al.[2], 30% felt that body armor caused their injury. Within subgroups, body armor was blamed for 29% of back injuries, 24% of neck injuries, and 27% upper extremity pain.

Carrying heavy loads cause discomfort and increase the energy expenditure of the soldier leaving him or her fatigued. Participants marched at 6 km/h for 30 minutes carrying consecutive loads of 30%, 50%, and 70% of their lean body mass.[45] There was a significant increase in oxygen consumption, ventilation, and heart rate as the load increased and there was a significant increase in perceived exertion with the 70% load.[45] In a treadmill road marching study, participants carried 0%, 15%, and 30% their body weight. Even at these lower weights VO2, heart rate, and expired ventilation increased significantly at each level while perceived exertion increased significantly while carrying 30% body weight only.[46] Increases in metabolic costs affect numerous aspects of the soldier's performance. This increased cost will affect the fatigue level of the soldier and increase the risk of injuries such as low back pain, knee pain, and stress fractures putting mission accomplishment in jeopardy.[47] All of these studies have been done in men. This study proposes to verify that load carriage is also a risk factor in women while deployed. If it is shown to be a risk factor, then it is possible that a training protocol designed to increase the women's ability to carry loads would decrease their injury rate. A study has shown that specific training can increase women's ability to overcome the weight of equipment they wear. After training, women were able to complete a loaded two mile run faster.[48] If load carriage is indeed identified as a risk factor, then raising their tolerance to a worn load will improve performance and reduce MSIs.

1.2.1.3 Lifting

While lifting tasks do not apply a constant load to the soldier as worn equipment does, they nonetheless increase stress on the body. Skeehan et al.[12] found that lifting was one of the most commonly reported causes of injury in deployed soldiers. Additionally, Cohen et al.[49] found that lifting objects was reported as the cause of 18% of the patients with back injuries that were medically evacuated to Landstuhl Regional Medical Center, Germany. Neither study assessed the type of lifting performed by soldiers. Previous research done in industry has identified frequent lifting, the weight of the object lifted, and lifting to a height above the waist as risk factors for injury.[50-53] The Manual Handling Operations Regulations from the Health and Safety Executive in the United Kingdom identified overhead lifting, carrying the object more than 10 m, frequency of lifting objects, and lifting the object from floor height as tasks that increase the mechanical stress on the back and can result in injury.[50] Frymoyer et al.[51] identified occupations requiring lifting of 20 kg or more at least twice daily to be associated with low back injury. Marras et al.[52] also found that workers categorized as high risk jobs (for back injury) had a greater lifting frequency than low risk jobs. These subjects, however were all males. The specific type of lifting have not been assessed before in military populations. Identifying if lifting objects is indeed a risk factor for female soldiers is a fist step. It is important to identify if components of lifting such as weight and frequency of lifting, as well as height of lifting and the initial height of load are risk factors of MSI. If particular components of lifting are identified by the proposed study, future reseach can establish a training program that can be implemented to increase the female soldiers' lifting ability specific to a task. It has been shown that proper training can increase the load that women can lift as well as the frequency of lifts they can accomplish.[48]

1.2.1.4 Weight Bearing Activities

Walking and standing have also been identified as risk factors for injury. In a study by Knox et al.[54], walking more than two hours was noted to be a risk factor for low back pain in workers.

Although this study did not measure distance, if we conservatively estimate a twenty minute per mile pace, two hours would represent six miles. Previous research in industry has shown that prolonged standing was also a risk factor for injury.[55-58] In a study of 1412 workers, those who stood for two hours or more had an increased risk of low back pain.[54] These finding are contradictory of findings in several other studies suggesting that walking and standing are not risk factors for injury.[59-62] Neither of these factors have been assessed before in a military population. Soldiers are required to do a lot of standing and walking when they are deployed to perform such occupational tasks as guard detail and dismounted patrols. Additionally, soldiers do not have private vehicles when they are deployed and have to walk everywhere, likely increasing their overall daily walking distance compared to living in the U.S. If one or both of these is identified as a risk factor in female soldiers, either training programs can be instituted to increase their endurance or ergonomic changes can be made to their environment in order to reduce injuries.

1.2.2 Physical Risk Factors

Risk factors for MSIs have been more extensively researched in U.S. military populations than deployed populations, mostly in basic training. In general, these studies focus on physical risk factors such as height/weight and fitness level. These physical risk factors are also often different in men and women. Lower fitness before basic training, fewer sit-ups, and low flexibility were risk factors for men but not women.[63] A separate study showed that shorter height was a risk factor for women whereas higher body mass index was a risk factor for men.[14] In fact, risk factors for men and women were found to be different so often that research studies began to investigate men and women independently. Allison et al. conducted a study in basic training to establish predictors for overuse injuries in men and women separately.[16] Of the female recruits, 38% suffered an overuse injury during basic training. Less initial push-ups and slower initial run time were predictors for overuse injury in women.[16] Of the men, 16% sustained an overuse injury. Six initial predictors [push-ups, age, weight, body mass index, number of dependents (spouse and children combined), and years of education] increased risk of injury in men. Logistic regression identified four predictors; age>25.5 years, BMI >31.1 kg/m^2, number of dependents > 2, and years of education <11.5. With men and women being susceptible to different physical risk factors for injury, analysis of risk factors for musculoskeletal injury while deployed should be done by sex as it is performed in garrison research.

1.2.2.1 Body Mass Index

Body mass index (BMI) is a measure that takes into account a person's height and weight. BMI adjusts body weight in terms of height. It has been shown to have a correlation of 0.7 with body fat.[64,65] BMI has not been shown to be a risk factor in several studies performed in recruits (basic training).[63,66,67] Conversely, studies done in a non-training military environments have found higher BMI to be a risk factor of MSI in men (there were not enough women in the samples to evaluate risk factors).[27,68] BMI has not been looked at as a risk factor in deployed environments nor in female soldiers who are not in training environments. The proposed study will fill this gap in knowledge by assessing BMI as a possible risk factor for injury in deployed female soldiers. BMI is potentially modifiable if shown to be a risk factor. Combination nutritional and fitness training programs could be implemented to decrease BMI before and during deployment to decrease risk of injury.

1.2.2.2 Endurance

Multiple studies have shown that less aerobic endurance, measured using a distance run, to be a risk factor for injury in both men and women in basic training.[63,66,67,69] Additionally, lower extremity endurance measured as a loaded step test has also been shown to be a risk factor in injuries in professional soldiers.[70] The majority of studies identifying lower endurance as a risk factor, have been done in recruits. This risk factor has been mostly ignored in professional soldiers. This study proposes to investigate if aerobic fitness is a risk factor for injury in professional female soldiers. A targeted rehabilitation training program was implemented in female recruits and resulted in a 30% decrease in injuries compared to an equivocal control group.[71] Additionally, the proposed study will not only use the current standard measure of the two mile run, but also the more functional loaded step test, previously used to study professional male soldiers.[70] There are almost no military occupational tasks that require a soldier to run for two miles but there are many tasks that require stepping up while under a load, such as road marching, climbing, engineer tasks, etc. Intervention programs that increase aerobic endurance in professional soldiers may be able to reduce injuries as they have done in recruits if aerobic endurance is found to be a risk factor for injury in this study.

1.2.2.3 Standing Balance

Injury occurs when force on the body is greater than the body's ability to resist it.[72] This force can be all at once, acute injury, or built up over time, overuse injury. When balance is poor the body may not be responding to force as quickly or be able to tolerate less force. Standing balance is essential for many activities of daily living. Impaired standing balance has been identified as a primary risk factor in the occurrence of falls and associated injuries in older adults. Poor standing balance has also been identified as a risk factor for injury in athletes in multiple studies.[73-79] The Y balance or Star Excursion test have been used in several of these studies as the measure of standing balance.[75-79] Specifically, those with asymmetrical movement (balance different on the left vs. right leg) were 2.7 times more likely to suffer a lower extremity injury and those with a decreased forward reach were 2.6 items more likely to suffer a lower extremity injury on the Y Balance Test (YBT).[75] Studies have demonstrated that programs targeted at increasing balance can reduce risk of injury.[80-82] A prevention program designed to increase the sensitivity of the mechanoreceptors would increase joint stiffness and increase the resistance of joints to force.[83] Using the YBT, the proposed study will test participants prior to deployment in order to assess if balance is a risk factor for injury in soldiers as well as athletes. Although not athletes, soldiers are asked to perform many physical tasks and often on uneven ground. Injuries in soldiers may decrease with balance training as it has with athletes.

1.2.2.4 Agility

Agility or mobility is similar to balance, except one has to be able to balance while quickly changing directions in motion. Soldiers have to sprint while on the battle field but rarely in a straight line. Soldiers also rarely walk in a straight line as they go about their occupational tasks. In fact, ankle sprain was second most commonly treated injury by a brigade physical therapist in Afghanistan.[20] Lower limb injuries accounted for 47% of the injuries and uneven terrain was one of the top five mechanisms of injury.[20] Several intervention programs containing agility training have been shown to reduce the risk of injury.[82,84] Agility training has also been shown to reduce the risk of re-injury.[85] The Illinois Agility Test is considered a gold standard of agility testing.[86-89] To date, no research has been done assessing if agility, in the form of a sprint with changes in direction, is a risk factor for injury. Yet, prevention programs targeted at agility decrease injury rates. Given the number of ankle sprains and lower limb injuries treated in Afghanistan, it is highly possible that agility is a risk factor for injury. Agility training methods such as those cited above could be implemented in order to reduce the number of injuries if shown to be a risk factor for injuries in female soldiers.

1.2.3 Psychosocial Risk Factors

Risk factors for injury do not have to be just physical in nature. Research has identified several possible psychological and social risk factors for injury in both sports and occupational research. Disruptions in sleep, increases in job stress, and less coping ability have all been identified as risk factors for injury. [90-93] None of these psychosocial factors have been investigated as risk factors for injury in military populations. Military deployments are characterized by an increase in operational tempo, changing job demands, and elevated exposure to numerous sources of stress (physical, mental, psychological, and interpersonal). The characteristics of military deployments make it very likely that soldiers are affected by sleep disruptions and increased stress. Many soldiers may also have poor coping skills. The current proposal intends to investigate these risk factors in female soldiers. Sleep, job stress, and coping skills are modifiable risk factors. If one or more of them prove to be risk factors in female soldiers, behavioral programs can be developed to reduce disruptions in sleep, decrease job stress, and increase coping skills. Modifying these risk factors could potentially reduce the high burden of injuries in U.S. Army units.

1.2.3.1 Sleep

Disruptions in normal sleep patterns are among the various sources of stress.[94,95] Operational tempo, job stress, and other deployment related factors may lead to sleep disturbances such as circadian desynchronosis, sleep deprivation, sleep latency, and waking after sleep onset.[94,95] Research suggests that deployed military service members report greater levels of fatigue and more difficulties with sleep during and after deployment than non-deployed personnel.[96,97] A survey study of 41,225 service members found that those who were deployed or had completed a deployment have shorter sleep durations and more trouble sleeping than those who have never deployed.[97] Those with posttraumatic stress disorder or combat exposure had the shortest durations of sleep. A substantial body of evidence has accumulated over the past several decades linking sleep restriction/loss to many physical and psychological effects that could increase the risk of injury such as: increased risk-taking behavior, decreased threat detection, impaired decision making, performance degradation, mood disturbances, and tunnel vision.[98-105] With disturbances in sleep causing impairments to one's ability to mentally process the environment and physically negotiate it, the risk for injury could increase. Disturbance/loss of sleep has also been associated with elevated risk of injury and illness.[90,91] In a study of 532 workers, those with sleep disturbances had double the risk of occupational injury.[106] In a study of 193 veterinarians, sleeping less than six hours was associated with injury.[107] No studies have been performed investigating a link between sleep loss/disturbance and injury in deployed service members. Although evidence suggests that women are more likely to be injured than men during training, it is unclear how (or indeed if) fatigue may differentially impact relative risk of injury during deployment in women.[108]

1.2.3.2 Job Stress

Job stress is another psychosocial factor that could increase the risk of injury. Job stress has been shown to have a physiological effect. Higher job stress can result in reduced blood flow to the extremities and muscles, increased blood pressure, increased corticosteroids levels, increased peripheral neurotransmitters, and increased muscle tension, all which could increase the risk of injury.[109] In a study of 533 workers, surges in workload, lack of decision making opportunities, high task variety, and lack of performance standards have also been linked to upper extremity musculoskeletal injury.[110] A lack of control at work has been associated with back injury in 114 workers.[111] In a civilian review of psychosocial factors and MIs, the authors found that there was evidence to suggest that perceived low control at work, high perceived work load, lack of social support by colleagues, and time pressure were related to musculoskeletal symptoms.[112] Multiple subcomponents of job stress, job demands, job control, job certainty, training, safety climate, skill under-utilization, responsibility for the safety of others, safety compliance, exposure hours, and job tenure were associated with injury or a near miss of injury in a second study of 408 construction workers.[92] Highlighting the differences in men and women again, high job stress (defined as high job strain and low coworker support) was significantly related to injury in women but not men in a study done in manual laborers.[113] Higher work stress has been demonstrated to increase risk for medical discharge in the military.[114] Despite the research in civilian occupations linking job stress to musculoskeletal injury, no studies have been done in military populations. In an occupation with the potential for high stress such as the military, studies investigating the effect of job stress on musculoskeletal injury are important. With the demonstration of the differing effects of job stress on men and women in the previously mentioned study, further research is needed on the effects of job stress in military women.

1.2.3.3 Coping

With stress being linked to injury in industry, the ability to cope may also be associated with injury. A review study noted that injured athletes have been less able to cope with life events than their non-injured counterparts.[115] A life event is an event that results in major changes in the life of those affected examples included marriage, the death of a close friend, or the loss of a job. A life event occurring in the last 12 months has been linked to injury in numerous sports.[115] Studies have noted that life events and poor coping skills were linked to injury.[116,117] Higher social support, a sub component of coping skills, has been shown to decrease the negative effects of life events on injury frequency and severity in several athlete studies.[118-121] A study by Petrie was able to identify coping skills as a predictor of the number of days of limited participation in sports due to injury.[93] Several retrospective studies have shown that injured athletes scored lower on coping skills than non-injured athletes.[118,122,123] Deploying to a combat zone would qualify as a life event. It stands to reason that soldiers with better ability to cope would be less affected by this life event as well as other life events often concurrent with deployment (death, divorce, etc) and sustain less injuries. Despite the research in athletes indicating that low coping skills may be associated with injury, no studies have been done on soldiers deployed to combat zones. Additionally, the aforementioned studies did not assess differences in the effect of coping skills on injury in men vs. women. The studies were done on single sex sport teams. Coping skills could possibly be improved using education. If it were shown that poor coping skills were associated with injury, further research could investigate the ability of coping training to decrease injury.

1.3 SIGNIFICANCE

MSIs cause a serious drain on resources and decrease the combat effectiveness of units.[2,9,12] The percentage of soldiers suffering from MSIs is up to 20% higher while deployed than in the U.S.[25,27,68] To date, studies have only investigated very broad occupational related risk factors for MSIs in a deployed environment.[2,9,12] These studies did not identify risk factors for each sex but for the overall group, of which at least 80% were male. In basic combat training studies, risk factors and mechanisms of injury for men and women have been shown to be different.[27,63] No studies have assessed psychosocial risk factors for injury during deployment. MSIs are decreasing the available work force in combat zones possibly putting lives and missions at risk. It would stand to reason that risk factors and activities associated with MSIs in combat zones would also be different in men and women. By identifying risk factors, prevention programs can be developed to address these factors. By addressing the risk factors individually in soldiers, the number of MSIs could be reduced. This would reduce the days of lost duty as well as the number of musculoskeletal discharges in the U.S. Army, potentially saving billions of dollars. The purpose of this prospective cohort study is to identify risk factors for musculoskeletal injury in female soldiers deployed to Afghanistan.

1.4 PILOT DATA

Pilot data was collected from the 12 month deployment of the 5th Stryker Brigade Combat Team, 2nd Infantry Division to Afghanistan in 2009-2010, Table 1. This was a retrospective cohort study with 593 subjects (57 women and 536 men). For the men, the mean ± SD age, height, weight, and BMI were 26.5 ± 5.8 years, 174.2 ± 11.9 cm, 83.2 ± 13.3 kg, and 27.4±5.2 kg/m^2, respectively. For the women, these values were 27.4 ± 7 years, 158.0 ± 12.5 cm, 64.4 ± 9.2 kg, and BMI 26.0±4.6 kg/m^2. Of the 593 soldiers, 268 (45%) reported at least one MSI and there were a total of 597 reported injuries. Of these MSIs, 95% occurred during occupational activities. Not all soldiers were deployed for the whole 12 months of deployment. Of those deployed for only three months, 63% were injured. Of those deployed for 3-6 months 15% were injured. Of those deployed for 6-9 months, 43% were injured and 48% of those deployed for 12 months were injured. Subset analysis was done by gender, 61% of women were injured and 44% of men. Time wearing body armor, the average load worn, the average weight of objects lifted, and the number of times objects were lifted per day were all significantly associated with MSI in women, Table 1. For the men older age, higher enlisted rank, longer time spent standing, heavier load worn, more days per week lifting objects, and longer duration of strength training sessions were all significantly associated to injury (data not shown). The risk factors for injury were different in men than women.

The study with the 5th Stryker BCT was a retrospective cohort study. There were several flaws in this study due to study design. Data was only collected at the completion of the study so no comparison to pre-deployment characteristics was possible. Injuries could only be associated with activities during the deployment. The proposed study will collect fitness and psychosocial data prior to deployment in order to identify risk factors for injury unrelated to deployment activities. The 5th Stryker BCT study also only assessed injury from self-report. The proposed study will utilize an electronic medical records review as well as self-report in order to increase the accuracy of reported injuries. The 5th Stryker BCT study asked how long soldiers were deployed but did not ask at what point during the deployment the injury occurred. The data above states that those who were deployed for less than three months or longer than six months had higher injury rates. This suggests that more injuries may occur in the first three months of deployment and in the last six months, however this was not truly assessed in the previous study. The proposed study will not only document what injuries occur and how, but also when. Finally, the study was underpowered for most analysis addressing women only. Further study in female soldiers investigating not only occupational activity risk factors but also fitness and psychosocial risk factors in a properly powered study is necessary.

Table 1. Pilot Data Relative Risks

Variable	Level	Subjects	% Injured	RR 95% CI	Chi 2	p value
Age (yrs)	≤ 29	40	57.50%	1	0.862	0.391
	≥ 30	17	41.70%	1.23 (.77-1.81)		
Rank	E1-4	35	57.1	1	4.54	0.103
	E5-9	18	77.8	1.36 (.89-2)		
	Officer/Warrant	4	25	.44 (.08-1.33)		
Primary Occupation	Office Work	26	53.80%	1	1.55	0.213
	Physical Work	30	70.00%	1.3 (.86-2.07)		
Amored Vest Wear (hrs)	0-4 hours	40	55.00%	1	4.195	0.041
	≥ 5 hours	14	85.70%	1.56 (1.02-2.23		
Time Spent Standing (hrs)	0-8 hours	24	54.20%	1	0.604	0.437
	>8 hours	31	64.50%	1.19 (.77-1.94)		
Miles Walked	0-4 miles	37	54.10%	1	2.4	0.121
	≥ 5 miles	20	75.00%	1.39 (.91-2.06)		
Load Worn	≤ 30lbs	41	51.20%	1	5.17	0.023
	≥ 31lbs	14	85.70%	1.67 (1.09-2.43		
Time Load Worn (hrs)	0-4 hours	34	55.90%	1	0.629	0.428
	≥ 5 hours	21	66.70%	1.19 (.75-1.83)		
Heaviest Load Worn	0-25 lbs	17	47.10%	1	1.96	0.376
	25-50 lbs	20	65.00%	.72 (.38-1.28)		
	>50 lbs	19	68.40%	1.05 (.66-1.69)		
Time Wearing Heaviest Load (hrs)	0-4 hours	39	68.40%	1	0.94	0.332
	≥ 5 hours	16	64.00%	.78 (.42-1.25)		
Days Performing Lifting	1-4 days	31	61.30%	1	0	0.985
	5-7 days	26	61.50%	1 (.65-1.53)		
Ave Weight of Objects Lifted	20-50 lbs	30	46.70%	1	6.626	0.01
	≥ 51lbs	22	81.20%	1.75 (1.15-2.79		
Times Lifted Objects/Day	1-4	35	51.40%	1	4.62	0.032
	≥ 5	17	82.30%	1.6 (1.05-2.41)		
Distance Objects Carried (ft)	≤ 50	34	64.70%	1	0.168	0.682
	≥ 51	17	58.80%	.91 (.53-1.4)		
Height Object Lifted	Waist Height	30	53.30%	1	2.017	0.156
	Chest Height	22	72.70%	1.36 (.88-2.12)		
Cardiovascular Exercise Performed (days/week)	0-3 days	22	59.00%	1	0.04	0.841
	4-7 days	34	61.80%	1.05 (.69-1.69)		
Cardiovascular Exercise Session Duration (min)	≤ 45	24	54.20%	1	0.755	0.385
	≥ 46 min	32	65.60%	1.21 (.79-1.97)		
Strength Training Performed (days/week)	0-3 days	33	63.60%	1	0.165	0.685
	4-7 days	24	58.30%	.92 (.58-1.39)		
Strength Training Session Duration (min)	≤ 30 min	19	57.90%	1	0.148	0.7
	≥ 31 min	38	63.20%	1.09 (.72-1.82)		

1.5 OBJECTIVES/SPECIFIC AIMS/RESEARCH QUESTIONS

The purpose of this prospective cohort study was to investigate modifiable risk factors for musculoskeletal injury in women serving in Afghanistan.

Specific Aim 1: Describe the injuries sustained by female soldiers while deployed to Afghanistan.

Hypothesis 1: The most commonly injured anatomical region will be the low back, the most commonly self-reported cause of injury will be lifting and carrying for work, and most injuries will occurring during the first three months of the deployment.

Specific Aim 2: Determine physical and occupational risk factors for MSIs in women assigned to a BCT deployed to Afghanistan.

Hypothesis 2.1: Lower body muscular endurance (lower step endurance and slower two mile runtime), poor balance, and slower agility times will be positive predictors for MSI.

Hypothesis 2.2: More demanding occupational tasks (wearing more weight, lifting heavier objects, and walking further) will be positive predictors of MSI.

Specific Aim 3: Determine psychosocial risk factors for MSIs in women assigned to a BCT deployed to Afghanistan.

Hypothesis 3.1: Pre-deployment scores indicating lower coping, abnormal sleep patterns, and higher job stress will be positive predictors of MSI in women.

Hypothesis 3.2: Deployment scores indicating lower coping, abnormal sleep patterns, and higher job stress will be positive predictors of MSI in women.

1.6 RESEARCH DESIGN

This is a prospective cohort study that investigated risk factor for musculoskeletal injury in women deployed to Afghanistan. Women organically assigned to three BCTs deploying in the spring, summer, or fall of 2012 were recruited. Prior to deployment all the women were briefed and those that volunteer were consented to participate in the study. No soldiers participated in any aspect of the study without prior informed consent. After being consented, the women participated in pre-deployment testing involving surveys, height and weight, and performance testing. Pre-deployment variables included demographics, injury history, type of occupation and activities performed in occupation, aerobic fitness, agility, muscle endurance, balance, coping ability, sleep, and job stress. Post deployment testing included occupational activity level, coping ability, sleep, job stress, and deployment injury history. Injuries were tracked during deployment using the Theater Medical Data Store (TMDS). Upon return from deployment, participants completed surveys only, no physical testing was performed.

1.6.1 Primary Outcome Variable

The primary outcome variable of the study was musculoskeletal injury. A musculoskeletal injury is defined as any injury to muscle, tendon, bone, ligament, nerve, or joint that results in intermittent pain lasting for at least twenty-four hours which impairs the soldier's ability to perform her occupational tasks or physical training.[124] These must be new injuries or recurrence of a completely healed injury (participant has no pain and no negative effects on ability to perform occupational tasks before deploying). Injuries that participants had at the time of deployment were not included in injury incidence calculations.

1.6.2 Participant Population

All women in the BCT were briefed on the study. Results of the study are generalizable to women in the U.S. Army deploying to Afghanistan. Approximately 150-300 women are assigned to each BCT.

1.6.3 Inclusion and Exclusion Criteria

Inclusion Criteria

All female soldiers assigned to the BCT with the intention of being deployed for the entire deployment will be offered the opportunity to participate in the study.

Exclusion Criteria

Women who know beforehand that during the deployment period they will leave the Army (Expiration of Term of Service, ETS), move to a new unit (Permanent Change of Station, PCS), or retire before the completion of the deployment will not be included in the study (they would need to return to the U.S. before the completion of the deployment to ETS/PCS or retire).

Male soldiers and soldiers who are not assigned to the BCT are not eligible.

1.6.4 Description of the Recruitment Process

All female soldiers were notified by their units when the study briefings were conducted. Soldiers have four weeks of vacation just prior to deployment. They are unavailable at this time and therefore briefing and data collection occured up to two months prior to deployment. The soldier's chain of command was not present for the briefing. Only the principle investigator (PI) or associate investigators (AI) conducted the briefings and consent participants. Consent briefings were offered at multiple times over several days in order to make it more convenient for soldiers. Soldiers in each session were briefed on the purposes of the study and study procedures. The PI or AI then went over the consent form and inclusion and exclusion criteria check list with the soldiers. Any questions that the soldiers had were answered and the soldiers were consented.

1.6.5 Data Collection

Previous deployment studies determined injury prevalence or incidence by using self-report surveys. Skeehan et al.[12] and Sanders et al.[9] used surveys given out to service members at the airport as they were returning home either for vacation or for the end of their deployment. Konizter et al.[2] distributed surveys at the end of the deployment but before the unit left Iraq. Using a survey to measure injury incidence or prevalence has the benefit of capturing non-reported injuries. A military study has shown that 12% of injuries in women and 24% of injuries in men go unreported (the soldier does not seek medical care for the injury).[125] Additionally, survey method could also capture injuries that were documented with paper notes or electronic notes that were not uploaded into the databases, which is often the case with injuries treated in deployed environments. One problem with all three of these studies is they did not assess at what point in the deployment the injury occurred. They all recorded cumulative incidence. The disadvantage to this method is that one cannot observe if there is a pattern as to when in the deployment the injuries are occurring. In the proposed study we will assess when during the deployment the injury occurred. Another negative to this self-report method of injury surveillance is that it requires the soldier to remember the injuries as well as know what the diagnoses were. Participant recall becomes worse over time and these soldiers were being asked to remember injuries over the length of their deployment, 9-12 months. The proposed study made use of both survey and medical record review to establish incidence rates of MSIs which is a better inclusive surveillance method and an improvement over previous deployment studies.

1.6.6 Pre-Deployment Data Collection

Pre-deployment data collection took place up to eight weeks prior to deployment. Deployment departure times fluctuate constantly up until the last soldier boards the plane and for this reason it was impossible to accurately predict exact deployment dates. Every attempt was made to keep pre-deployment data collection within four weeks of deployment.

1.6.6.1 Army Physical Fitness Test

Participants will take the Army Physical Fitness Test (aerobic and muscular endurance) (APFT) with their units less than six months prior to the testing day. The APFT was not conducted by the study staff. The APFT was conducted by the unit as part of their standard operating procedures. This ensures that the participants were motivated to perform at their best since the unit record APFT effects promotion and evaluation. The APFT measures the soldiers' upper and lower body muscular endurance.[126] The APFT includes, in order, two minutes of push-ups, two minutes of sit ups, and a two mile run. The soldier's shoulders must reach the height of her elbows in order for the push-up to count. The soldier is not allowed to lift her hands or feet off the ground and cannot place her knees on the ground or the event is terminated. Previous studies on push-ups indicate a good correlation with total upper body strength and endurance.[127] The base of the soldier's neck must reach the vertical plane created by the base of her spine during sit-ups and the soldier is only allowed to rest in the up position. The two mile run is commenced within ten minutes of finishing the sit-ups. While walking is allowed, it is highly discouraged. The two mile run has shown good or excellent correlation to VO_2max in subjects.[127,128] The composite score is calculated by adding the adjusted score for each event. Raw score for each event (number of push-ups and sit-ups and run time) is converted to scores using a age stratified table.[126] The participants reported their composite score as well as raw score for each event.

1.6.6.2 Data Collected by Research Staff

Participants were only required to participate in testing for one day for this study. The uniform for testing was the combat uniform. While waiting and upon completion of the physical testing, all participants completed the surveys. Additionally, during the testing day height and weight was measured for all participants. Participants with profiles (activity restrictions due to injury) did not complete events restricted by their profile but did complete all others and surveys. The Illinois Agility Test was performed either in a gym. On the day of testing all participants performed, in order, the following physical tests and surveys.

1.6.6.3 Physical Tests

1) Y Balance Test (YBT).

The YBI is a dynamic balance test performed while standing on one leg and it.[75] The Y Balance Test is based off of the Star Excursion Balance Test. The Star Test originally tested balance in eight directions. After study, it was discovered that three directions were the best predictors for injury and these three became the Y Balance Test.[75,129] These tests have been utilized in previous studies to assess physical performance, identify chronic ankle instability, and identify athletes at greater risk for lower extremity injury.[75-79] Specifically, those with asymmetrical movement (balance different on the left vs. right leg) were 2.7 times more likely to suffer a lower extremity injury and those with a decreased forward reach were 2.6 times more likely to suffer a lower extremity injury.[75] The YBT has been shown to have good intra-rater reliability (ICC: 0.85 to 0.91) and good inter-rater reliability (ICC: 0.99 to 1.00).[130]

During the YBT, the participant stands on one leg on the center plate. While maintaining single leg balance, the participant uses the free leg to reach as far as possible in three directions (anterior, posteriomedial, and posterolateral directions in relation to the stance foot) by pushing the block. A demonstration will be made and participants will be allowed to practice six times with each leg before testing in order to reduce the learning affect. Three trials in each direction for each foot will be collected. The trial will be discarded and repeated if the participant (1) fails to maintain unilateral stance, (2) lifts or moves the stance foot from the grid, (3) touches down with the reach foot, or (4) fails to return the reach foot to the starting position.[75] To normalize reach length based on participant's limb length, lower limb length (anterior superior iliac spine to the most distal portion of the medial malleolus) was calculated. To express reach distance as a percentage of limb length, the normalized value was calculated as reach distance divided by limb length then multiplied by 100. Composite reach distance and asymmetry values were calculated.

Figure 1. Y Balance Test

2) Illinois Agility Test.

The Illinois Agility Test measures agility and has been shown valid to differentiate levels of agility. [90,91] The Illinois Agility Test is considered the gold standard agility test.[86-89] It is set up with four boundary cones, 10 meters long x 5 meters wide. An additional four cones are set up in the center of the testing area 3.3 meters apart. The test starts lying face down behind and next to cone 1 (hands should be at shoulder level ready to push up). On the command "Go," the stopwatch is started. The participant gets up as fast as possible and runs around cone 2, around cone 3 weaving through cones 4-6 and back down weaving through cones 6-3. Finally, she sprints from cone 3 around cone 7 and down across the finish line at cone 8. All of the sprinting is in the forward direction. Test result is the time in seconds taken to complete the task. All participants practiced this event three times before completing the record test (walk, jog, run). Participants had at least five minutes of rest between the Illinois Agility Test and the loaded step test.[131]

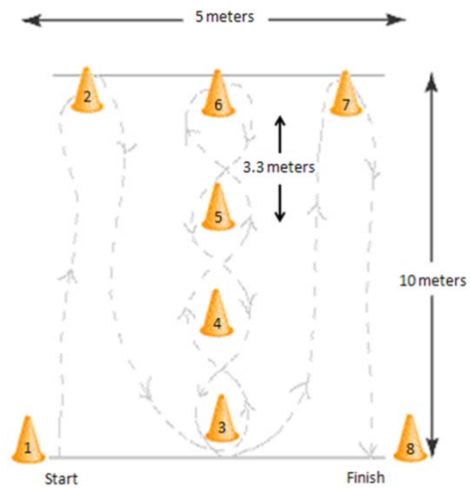

Figure 2. Illinois Agility Test set up and run path

3) Loaded step test.

The loaded step test measures lower extremity muscular endurance. [70] The participant will don a 17 kg vest. Starting with the left leg on the 0.3 m step, the participant will step up and down to a metronome at a rate of 50 steps per minute (0.42hz). The loaded step test was first described in men weighing an average of 75.3 kg and used a step height of 0.4m. [70] To account for the difference in weight between men and women, the weight will be reduced by 15%. This reflects the 15% difference in weight between the men performing the original test and the women in the pilot sample. Additionally, in deployed environments women wear their body armor often but seldom wear a back pack beyond carrying it to and from work. This can be seen in the pilot data, the average perceived weight worn by female soldiers was 26.4 lbs which is consistent with the weight of a small armored vest. Therefore a uniform weight vest used to simulate body armor will be used instead of a backpack as this is more functional. The step height will be reduced to 0.3 m as previously done in military step tests which used a height of 0.4 m for men and 0.3 m for women.[132,133] During the loaded step test, the left leg will remain on the step at all times. The right foot must be placed flat on the step before stepping down. The body must be straightened up at every step. The test will be terminated when the participant can no longer keep the pace or can no longer straighten the body. The participant may receive one verbal warning to keep up with the pace before the test is terminated. The test will also be terminated if the participant has any pain. The right leg will be tested in the same manner as the left. The cut offs used in previous research for prediction of back injury was 70 steps and knee injury was 80 steps in elite male soldiers.[70] Of elite male soldiers failing to complete 80 steps for both legs of the step test, 92% suffered serious knee injuries.[70] In this study we used a ten minute cut off.

Figure 3. Starting position for the loaded Step Test

1.6.6.4 Pre-Deployment Surveys

1) The Pre-deployment Afghanistan Activity and Injury Survey (Appendix A) was used (a modified version of a previously used survey from the U.S. Army Research Institute of Environmental Medicine) to collect demographic information and injury information.[134,135] This survey solicited demographic information, height/weight, information on fitness training, and occupational activities.

2) Pittsburgh Sleep Quality Index (PSQI) (Appendix B) is a self-administered questionnaire that provides a comparable quantitative measure of sleep quality over the past month. [136] It will be

used to assess the previous month. It is a 19 item questionnaire. Scores can range from 0-21, with scores greater than five indicative of poor sleep quality. The sensitivity is 0.9 and the specificity is 0.9 when using the cut off score of 5 for identifying those with poor sleep quality. The PSQI is able to accurately distinguish normal sleepers from disordered sleepers. Compared to the results of polysomnography (PSG), the PSQI is equal to PSG in estimating sleep latency, but is better at estimating the past month's sleep duration and efficiency. This scale has a Cronbach's alpha of 0.83 which is indicative of high internal consistency. Evaluation of the clinical properties of the PSQI over an 18-month period revealed acceptable measures of internal consistency, and validity. An injury study conducted in ballet dancers demonstrated a significant correlation between low global scores on the PSQI and length of time injured, r = -0.45 (p=.001).[137] Participants answered the questions for their sleep pattern over the last month for the pre-deployment version and over the deployment for the post deployment version.

3) Job Stress will be measured using the Job Content Questionnaire – 14 (JCQ).[138-142] (Appendix C) This is a psychosocial job assessment questionnaire. The scale provides a measure of the degree of decision latitude or job control (eg, opportunities to participate in decision-making processes and learning and job autonomy) (9-items) and psychological job demands, which includes quantity of work and degree of time and work constraints (5-items). Answers range from "strongly disagree" to "strongly agree." Scores can be calculated using a subscale analysis and algorithm for composite score.[142] The Cronbach's alpha coefficient for women is 0.73.

4) Coping will be measured using the Brief COPE.[143] (Appendix D)

The Brief COPE is a self-administered questionnaire designed to quantify a participant's ability to cope. Several studies have shown that injured athletes scored lower on coping skills than non-injured athletes.[118,122,123] It contains 28 items and is rated on a four-point Likert Scale, ranging from “I haven’t been doing this at all” (1 point) to “ I have been doing this a lot” (4 points). Higher score is indicative of greater ability to cope. This scale covers 14 different dimensions. These are self-distraction, active coping, denial, substance use, use of emotional support, use of instrumental support, behavioral disengagement, venting, positive reframing, planning, humor, acceptance, religion and self-blame. Cronbach’s alpha for this questionnaire was 0.75.[144] Test–retest reliability was found to be good (ICC = 0.87).[143] Both behavioral disengagement and self-blame have been associated with injury in previous research.[145] The Brief COPE has been used as a standard for measuring coping in previous studies.[144,146-148] In this study we will compare total score to injury incidence.[149]

1.6.7 Post-Deployment Data Collection

Post-deployment data collection was done within four weeks of the soldier’s arrival back in the U.S. Post-deployment data collection was included as part of the soldier’s redeployment processing which took place within two weeks of arriving back in the U.S. Soldiers did not perform unit physical training or occupational tasks nor do they go on vacation until redeployment processing was complete.

1.6.7.1 Medical Records Data

Injuries were tracked by using a medical records review from Theater Data Medical Store (TMDS). Armed Forces Health Surveillance Center (AFHSC) provided data from the TMDS upon completion of the deployment. Subject SSN and name will be supplied to AFHSC and AFHSC will query all ICD9 codes listed that are within the criteria (710-739, 781, 784, 793, 800-999, and E800-999), dates of visits with the above codes (first time visits only) and any profile (limitation to duty) information. Any information containing SSNs was transmitted to and from AFHSC through encrypted email. Any data was stored on password protected computers. Any mailed information was sent with a signature required. The chart review did not include injuries that were never treated or injuries that were treated and not documented electronically. In the case where an injury appears in both the survey and the medical records, the information from the medical record will be considered as more accurate. In the case when injury does not appear on medical record but only in self-reported surveys, the survey information will be considered correct.

The ICD9 codes and their group definitions are listed below.

710-739 **–** Diseases of the Musculoskeletal System and Connective Tissue

781 **–** Symptoms involving nervous and musculoskeletal systems

784 **–** Symptoms involving the head and neck

793 **–** Nonspecific abnormal findings on radiological and other examination of body structure

800-959 **–** Injury and poisoning

E800-999 Supplementary classification of external causes of injury and poisoning

1.6.7.2 Post-Deployment Surveys

1) The Post-Deployment Afghanistan Activity and Injury Questionnaire (Appendix E) was used (previous versions were used by the U.S. Army Research Institute of Environmental Medicine) to collect demographic information, injury information (to capture injuries that were not added to the medical record), and occupational activity levels.[134,135] The following occupational tasks were measured using a self-report survey: weight of the average load worn by the soldier, time

wearing body armor, weight of the heaviest load worn by the solder, time wearing the heaviest load, weight of objects lifted, number of times objects lifted per day, height object lifted to and from, miles walked, and time spent standing. All weights were perceived weights.

2) Pittsburgh Sleep Quality Index

3) Job Content Questionnaire – 14

4) Brief COPE

1.7 STATISTICAL CONSIDERATION

Incidence rates for MSIs was the dependent variable (outcome) for all analyses. MSI was assessed from medical records and self-report. Incidence rate were calculated as the ratio of the number of participants suffering a new injury to the total number of participants. Alpha was set at 0.05.

1.7.1 Hypothesis 1

The most commonly injured anatomical region will be the low back, the most commonly self-reported cause of injury will be lifting and carrying for work, and most injuries will occurring during the first three months of the deployment.

Post-deployment injuries will be described as a percentage of the total for body region injured, reported cause of injury, injury date, diagnosis, number of day of limited duty, duration of injury, and whether the injury occurred on duty, off duty, or on vacation.

1.7.2 Hypothesis 2.1

Lower body muscular endurance (lower step endurance and slower two mile runtime), poor balance, and slower agility times will be positive predictors for MSI.

The independent variables for hypothesis 2 are: total 2 mile run time (ratio), time for step test (average between both legs) (ratio), Illinois Agility time (ratio), asymmetry on the YBT (ratio), and composite score on the YBT (interval). Dependent variables were associated with MI using chi square for categorical variables and point bi-serial for continuous variables.

For hypothesis 2, we used the same three steps to the inferential statistical analysis as described in hypothesis 1. Step 1 consisted of analysis of bivariate correlation of each dependent variable and injury incidence. Continuous variables were analyzed using point bi-serial, whereas categorical variables was analyzed with chi square. Dependent variables correlated to MSI with a p-value of 0.1 or less (and not highly correlated to other dependent variable) were considered for input into the logistic regression in step three.

Step 2 consisted of the calculation of relative risk (RR) for all variables as described in Hypothesis 1. Justification for the creation of two functional levels for each physical factor follows:

a. Total 2 mile run time was be separated into two levels at the 35th percentile which allowed for a 25% difference to be detected with the proposed sample size.
b. Steps completed (average between both legs) were separated into two levels, 0-70 and over seventy as established in previous research.[70]
c. Illinois Agility time was separated into two levels at the 35th percentile.
d. Asymmetry on the YBT as defined as a difference between the left and right leg of

greater than 4 cm in one direction was recorded as present or absent.[75]

e. Composite score on the YBT calculated as the sum of the three normalized reach distances divided by three times limb length, multiplied by 100.[75]

Step 3 see below, Hypothesis 2, Step 3.

1.7.3 Hypothesis 2.2

More demanding occupational tasks (wearing more weight, lifting heavier objects, and walking further) will be positive predictors of MSI.

The independent variables for hypothesis 2 were the occupational activities participated in during deployment: time wearing body armor (ratio), time standing (ratio), distance walked (ratio), weight of average load worn (ratio), heaviest load worn (ratio), days per week performing lifting tasks (ordinal), average weight of object lifted (ratio), average times lift object per day (ordinal), height lifted object from (nominal), and height lifted to (nominal). Lifting variables (weight, times lifted, days per week) were analyzed independently and combined into one inclusive lifting variable.

There were three steps to the inferential statistical analysis. Step 1 consisted of analysis of bivariate correlation of each dependent variable and injury incidence. Continuous variables were analyzed using an independent sample t-test or Mann Whitney U test with injury as the dichotomous dependent variable. Variables recorded as ordinal, will first be split at the median to create two categories that will be analyzed with chi square to assess associations with injury using two levels split at the median with the exception of height the object is lifted to or from which it is lifted. Height lifted from were analyzed as floor height and above floor height.

Height lifted to was categorized as overhead or chest height and below.

A correlation matrix was constructed for all variables correlated to MI with a p-value of 0.1 or less. These variables were correlated to each other. Those that correlated to each other with a correlation coefficient of 0.8 or greater were considered to have a high level of multicolinearity. Of those with a correlation of greater than 0.8, only the one most correlated to MSI were considered for input into the logistic regression in step three.

Step 2 consisted of the calculation of relative risk (RR) for all variables. RR is the ratio of the incidence of injury in the exposed divided by the incidence of injury in the unexposed.[150] The unexposed was represented as the baseline level and the exposed is the tested level. RR is the likelihood that someone who has been exposed to the risk factor will become injured. RR adds additional information not provided by t-test/Mann Whitney U test or chi square. Chi square provides information on the association of the variable to MSI only. RR provides information on the magnitude of the difference in risk between the baseline level and the tested level. This information can provide commanders with information on the increase in risk of MSI to their female soldiers if they choose to have them operate at these different levels. RR analysis has been used multiple times in military injury risk factor studies.[5,13,14,63,71,151]

For step 2, the continuous variables were collected and organized into categorical data to allow the calculation of RR. The level least likely to result in injury served as the standard or baseline to which the other were compared, for example the lowest weight strata for equipment worn was the comparison level. Justification for the creation of two functional levels of each occupational activity follows:

a. Time wearing body armor was separated into three levels, 0, 1-4 hours and over four hours as established in previous research.[2]

b. Time standing was separated into two levels, 0-4 hours and greater than four hours. There is no set amount of standing time used in the literature.[152,153] Four hours was used in this study as half the standard length of a civilian work day.

c. Distance walked was separated into two levels, 0-2 miles and greater than two miles.

d. Weight of average load worn was separated into three levels, 0, 1-29 and 30 lbs. and above. This is the approximate weight of wearing only the body armor, size small.[154]

e. Heaviest load worn was separated into two levels, 0-48 and over 48 lbs. This is consistent with a regulation weight fighting load for the U.S. Army.[155] It would generally include the body armor plus a pack.

f. Days per week perform lifting tasks will be separated into two levels, 0-3 days and more than three days.

g. Times lifting per day was separate at the median.

h. Height lifted from was analyzed as floor height and above floor height. Lifting from the floor has been shown to have the greatest risk of injury.[53]

i. Height lifted to was categorized as overhead or chest height and below. Lifting to over the head increases the force applied to the body.[53]

Step 3, see below.

1.7.3.1 Hypothesis 2 Step 3

Step 3 consisted of logistic regression. Variables from 2.1 and 2.2 found to have an association to injury with a p-value < 0.1 during step 1, or a significant increase in risk during step 2, were considered for the simultaneous logistic regression in order to establish the logistic model of four variables or less best able to predict injury. If the continuous variable was associated with injury it was input into the regression as continuous. If only the relative risk was significant, the variable was input into the regression in the dichotomous form used to calculate the relative risk. All subset logistic regression was used as a starting point. The best equation was found by manipulating which variables are included and measuring the impact of adding or subtracting particular variables from the equation.

1.7.4 Hypothesis 3.1

Pre-deployment scores indicating lower coping, abnormal sleep patterns, and higher job stress will be positive predictors of MSI in women.

Independent variables for hypothesis 3.1 were the pre-deployment measures of the: the Brief COPE (ratio), the JCQ (ratio), and PSQI (ratio). Dependent variables was associated with MSI using chi square for categorical variables and t-test/Mann Whitney U test for continuous variables. For hypothesis 3.1, we used the same three steps to the inferential statistical analysis as described in hypothesis 1. Step 1 consisted of analysis of bivariate correlation of each dependent variable and injury incidence. Differences between these dependent variables and MSI was assessed using t-test/Mann Whitney U test. Independent variables associated to MSI with a p-value of 0.1 or less (and not highly correlated to other dependent variable) were considered for input into the logistic regression in step three.

Step 2 consisted of the calculation of relative risk (RR) for all variables as described in Hypothesis 1. Justification for the creation of two functional levels for each physical factor follows:

a. Two levels was used for the PSQI, scores were categorized as five and below and above five as shown to be the most predictive cut off according to previous literature.[136]
b. The JCQ composite score was split at the 35th percentile.
c. The JCQ score was also be split into "high job strain" and "non-high job strain." High job strain was defined as persons who score above the median for job demands and below the median for job control.[142]
d. Brief COPE was separated into two levels at the 35th percentile.

Step 3 consisted of logistic regression as described in Hypothesis 1.

1.7.5 Hypothesis 3.2

Deployment scores indicating lower coping, abnormal sleep patterns, and higher job stress will be positive predictors of MSI in women.

Statistical analysis for hypothesis 3.2 was conducted exactly the same as hypothesis 3.1 with the exception that the independent variables are the post-deployment measures of the Brief COPE, JCQ, and PSQI.

1.7.6 Sample Size Estimation

Sample size was estimated based on the primary hypothesis in each aim. Sample size estimations for logistic regression were based on a conservative 30% rate of injury. This assumes that approximately 10 injured participants are necessary to supply statistical power for each variable entered into the logistic regression. The only previous research study to look at injury incidence in women in a deployed environment found an injury rate of 50% in women.[11] Injury rates in mostly male populations have been recorded as 30% and 70% in deployed areas.[2,9] There are no more than four variables in any logistic regression. With a conservative injury rate of 30% this would require a sample size of 133.

The percent difference in injury detectable between those who are exposed to a risk factor and those who are not varies depending on the ratio of the exposed sample to the non-exposed sample. With a ratio of the number of exposed participants to the number of non-exposed participants (N2/N1) anticipated to vary between 0.35 and 1.3, depending on the variable (per pilot data), a percent difference in injury of 23-26% is detectable with a sample size of 133. A sample size of 133 will detect a correlation as low as r= 0.22 with a power of 0.84 using a point biserial analysis to assess associations between scores and injury.

A BCT contains 150-300 women. With a dropout rate of 25% at least 177 women are needed, Table 2. In a previous deployment study conducted by the PI, the dropout rate was 35% without eliminating those who would PCS/ETS or retire before completing the deployment. In this study those who know they will not finish the deployment will not be enrolled and this should decrease the dropout rate.

Table 2. Sample Size Estimation

Estimate Required Sample Size	133
Estimate Participant Drop Out	34
Estimate Participant Withdrawal	0
Total Enrollment Requirement	177

1.7.7 Confidentiality

All data will be stored at USARIEM but may be stored temporarily at UPITT for data processing. Paper data will be stored in a locked storage area. In the event that paper data needs to be transferred from USARIEM to UPITT or vice versa, signature required mail will be used. Electronic data will be stored on password protected computers and transferred with encrypted file exchange or encrypted email. Only the PI and AIs will be allowed to have access to identifiable data. Upon completion of the post deployment data collection, all names and social security numbers will be removed and pre and post-deployment data will be linked by participant number. A file linking names to participant numbers will be maintained at USARIEM for three years. Data will be stored for three years.

1.7.8 Risks

There is a slight risk of injury during the performance testing aspect of the pre-deployment testing. No injury is likely to occur, however if an injury occurs it will most likely be a muscle strain. Participants will warm up for 5 minutes prior to the Illinois Agility Test to avoid such injuries. Participants with profiles will not participate in events limited by their profile but will participate in all other events and surveys. Base medical clinics are located within 10 minutes of the testing area(s) and any participants that become injured will be transported to a base clinic. There is also a small risk that identifiable information will be compromised. All identifiable information will be handled by research personnel only. All data will be either stored in a locked facility or password protected.

1.7.9 Potential Benefits

There are no immediate benefits to the research participants. The purpose of this prospective study is to investigate risk factors for injury in order to lead to the creation of effective injury prevention strategies to benefit future deploying personnel.

1.8 ADVERSE EVENTS, UNANTICIPATED PROBLEMS, DEVIATIONS, AMENDMENTS, AND WITHDRAWLS

1.8.1 Likelihood of Adverse Events

Injury during performance testing – Less likely

Compromise of identifying information – Less likely

All adverse events will be reported immediately to the PI who in turn will notify the necessary personnel. All participants who become injured will immediately be sent for medical care. In the case of a compromise of identifying information, the information will be retrieved if possible and the person to whom the information pertains will be notified as well as the PI. Participants will continue to be followed after the occurrence of an adverse event unless they wish to withdraw.

1.8.2 Reporting Unanticipated Problems Involving Risks to Subjects or Others, Serious Adverse Events and Deaths to the IRB

University of Pittsburgh. An adverse event is any untoward or unfavorable medical occurrence in a human research participant, including any abnormal sign (e.g., abnormal physical exam or laboratory finding), symptom, or disease, temporally associated with the individual's participation in the research, whether or not considered related to the individual's participation in the research.

A serious adverse event is any adverse event temporally associated with the subject's participation in research that is fatal, life-threatening, permanently disabling, requires inpatient hospitalization, or results in congenital anomalies/birth defect, overdose or cancer, or based on appropriate medical judgment, may jeopardize the participant, or may require medical or surgical intervention to prevent one of the above outcomes. University of Pittsburgh IRB is the primary site for reporting of Unanticipated Problems Involving Risks to Subjects or Others and Serious Adverse Events. Reports will be simultaneously provided to the USARIEM HURC.

U.S. Army Research Institute of Environmental Medicine. An adverse event is any untoward or unfavorable medical occurrence in a human research participant, including any abnormal sign (e.g., abnormal physical exam or laboratory finding), symptom, or disease, temporally associated with the individual's participation in the research, whether or not considered related to the individual's participation in the research. A serious adverse event is any adverse event temporally associated with the subject's participation in research that is fatal, life-threatening, permanently disabling, requires inpatient hospitalization, or results in congenital anomalies/birth defect, overdose or cancer, or based on appropriate medical judgment, may jeopardize the participant, or may require medical or surgical intervention to prevent one of the above outcomes. University of Pittsburgh IRB is the primary site for reporting of Unanticipated Problems Involving Risks to Subjects or Others and Serious Adverse Events. Reports will be simultaneously provided to the USARIEM HURC.

H. University of Pittsburgh Reporting Instructions

Internal Adverse Events which are Unexpected, FATAL or LIFE-THREATENING, and Related or Possibly Related to the Research Participation must be reported to the UPITT IRB WITHIN 24 HOURS. (Note: It is recognized that the information available during this 24 hour period may not be sufficient to permit accurate completion of the required Adverse Event reporting forms. However, the IRB should, at a minimum, be notified of the fatal or life-threatening internal Adverse Event during this time frame, with subsequent follow-up submission of a more detailed written report.) Internal Adverse Events which are Unexpected, Serious (but not fatal or life-threatening), and Related or Possibly Related to the Research Participation shall be reported to the IRB within 5 working days of the investigator becoming aware of the reaction.

IRB Submission Process for Internal AEs. Submit 26 copies of the following:

- IRB Cover Sheet marked "Adverse Event"
- IRB adverse event report form
- Sponsor report form or FDA MedWatch report form
- OBA Serious Adverse Event Reporting Form For Human Gene Transfer Clinical Studies (if applicable)
- IRB protocol and consent form

- Modification request form, if applicable.

I. *USARIEM Reporting Instructions*

Expected adverse events which are not serious are reported to the HURC at the time of continuing review of the protocol. Unexpected (but not serious) adverse events which, in the opinion of the PI, are possibly related to participation in the research must be reported by the PI within 5 (five) working days to the HURC using the Adverse Event Report Form.

Unanticipated problems involving risk to subjects or others, serious adverse events related to participation in the study and all subject deaths should be reported within one working day by phone (508-233-4851/4811), facsimile (508-233-5391), or email (usariem.rqc@amedd.army.mil) to the USARIEM Human Use Review Committee and Commander. A complete written report should follow within 5 working days of the initial notice. Unanticipated problems will be reported to the USAMRMC Office of Research Protections, Human Research Protection Office. All unanticipated problems involving risk to subjects or others, serious adverse events, and all subject deaths will be promptly reported by phone (301-619-6240) by e-mail (IRBOFFICE@amedd.army.mil), by facsimile (301-619-4165) to the HQ, USAMRMC IRB, or sent to the U.S. Army Medical Research and Materiel Command, ATTN: MCMR-RP, 504 Scott Street, Fort Detrick, Maryland 21702-5012. A complete written report will follow the initial notification.

1.8.3 Amendments

Each amendment, or planned change to the protocol, will be submitted to the USARIEM HURC, using form HURC-6 to detail the specific change, with a copy of the revised and dated protocol and consent form. If the change does not increase the risk to greater than minimal and is otherwise a minor change that does not require review at a convened HURC meeting, the amendment may be implemented following approval of the HURC. Amendments which must be reviewed at a convened meeting will be subsequently approved by the USARIEM Commander prior to implementation. If the amendment does not potentially increase the risk to subjects from that posed in the original protocol, but is a major amendment requiring review at a convened HURC meeting, the HURC will recommend approval and the USARIEM Commander will approve the change prior to implementation. If the amendment is a minor change that does not require review at a convened HURC meeting, the amendment may be implemented following HURC approval. In these cases the HURC-approved amendment will be submitted to the USAMRMC ORP HRPO for acknowledgement. All amendments will also have to be approved by the UPITT IRB.

1.8.4 Withdrawal from Study Participation

If a participant withdraws from the study, data collected up until that point will be analyzed unless forbidden by the participant. All data will be secured as mentioned above. No further data or records review on that participant will occur. If the participant withdraws and does not want any of her data used, it will all be destroyed or deleted. There are no consequences to the participant for withdrawal. The PI may terminate the participation of a participant if she no longer meets the inclusion criteria or if she fails to complete the study.

2.0 A DESCRIPTION OF MUSCULOSKELETAL INJURIES OCCURING IN FEMALE SOLDIERS DEPLOYED TO AFGHANISTAN

2.1 SUMMARY

Each year musculoskeletal injuries (MSIs) result in thousands of lost duty days per brigade as well as thousands of medical discharges from the military costing billions of dollars. While women represent approximately 15% of the U.S. Army, and have higher incidence rates of MSIs than male soldiers, no known studies have investigated MSIs in women while deployed. Therefore, the purpose of this prospective cohort study was to investigate MSIs in female soldiers during a nine month deployment to Afghanistan and characterize body region injured, activity associated with MSI, and the month in which the first MSI occurred.

Female participants were recruited from three Brigade Combat Teams deploying during 2012. Participants completed a survey on demographics prior to deployment. Upon completion of the deployment, soldiers completed a second survey on occupational demands and MSIs.

Of the 160 women, 57 (36%) suffered 78 MSIs resulting in 1642 days of limited duty or 21 days per MSI, losing 10% of the available duty time to MSIs. Most injuries affected the knee (24%) or low back (18%). Soldiers attributed the majority of injuries (27%) to physical training. Thirty-seven percent of MSIs caused large limitations to physical training while only 4% resulted in large limitations to occupational tasks. Most MSIs (41%) resolved within three

weeks and most (37%) occurred before the fourth month of deployment.

Injuries to deployed female soldiers are costly in terms of lost duty time and medical costs. Prevention measures should target knee and low back injuries. Physical training is a major cause of MSI in women as well as men. Physical training should be further investigated to discover modifications capable of reducing injuries.

2.2 INTRODUCTION

With conflicts in both Iraq and Afghanistan occurring simultaneously, U.S. Army soldiers are spending more time deployed to combat zones. Over two million service members (Army, Navy, Marines, Air Force and Coast Guard) have deployed to these combat zones from 2000 to 2010 with 40% of service members deploying more than once.[1] Throughout these conflicts, musculoskeletal injuries (MSIs) have had a negative impact on our forces accounting for at least twice as many medical evacuations as combat injuries.[3-5] They are also the leading cause of ambulatory medical visits, both in the U.S. and while deployed to combat zones.[6-10]

Although there have been studies investigating the MSI incidence in female soldiers in training and in regular garrison Army environments (bases to which the soldier is permanently assigned as opposed to being deployed to combat zone or in training), to date, the rate of MSIs in female soldiers deployed to these combat zones is unknown. The studies investigating MSIs in deployed environments were made up of at least 80% men with no subset analysis performed on female soldiers.[2,9,11,12] Studies conducted on service members in garrison have found that women have a higher incidence rate of MSIs than men. Studies in basic training populations have shown a greater burden of MSIs in female soldiers than male soldiers with 45% to 57% of women sustaining a MSI compared to only 27% to 46% of men.[13-15]

Along with establishing the incidence rate of MSIs in deployed female soldiers, research needs to also determine which body region is most susceptible to injury and which type of MSI occurs most often in deployed female soldiers. The previous studies on deployed soldiers, most of which were men, demonstrated that the low back was the most commonly injured body region, representing 24% to 60% of all MSIs.[2,9] Conversely research conducted on military populations in non-deployed settings found differences in the proportions of anatomical regions injured between men and women.[15,24] In a study of 1,210 service members in training, women suffered ankle, upper extremity, and lower leg injuries the most, whereas men sustained a majority of ankle, back, and lower leg injuries.[24] In another study on trainees, men had more ankle/foot injuries than women.[15] This study investigating lower extremity injuries and the authors reported that women had predominately patellofemoral pain syndrome, ankle sprains, and iliotibial band syndrome; whereas men suffered similar injuries but in a different order of frequency, with iliotibial band syndrome being more prevalent, followed by ankle sprain and Achilles tendonitis.[15] A study of basic trainees reported that the injuries most suffered by male soldiers were low back pain, tendonitis, sprains, strains, and stress fractures, and for women it was strains, stress fractures, sprains, tendonitis, and knee pain.[14] These studies support that men and women in training suffer different injuries in different anatomical locations. It is unknown if this is true in deployed service members.

These MSIs affect not only the soldier but also the U.S. Army. The large numbers of soldiers suffering MSI can lead to a reduction in work efficiency and a decrease in combat strength in the U.S. Army. The average MSI can cause up to 18 days of limited duty, roughly ten times the number of limited duty days due to illness.[22,24,25] Studies conducted in training and garrison report that the limited duty rate for women due to MSIs can be twice as high as men.[26,63] In mechanics at Fort Bragg, 41% of men and 51% of women received limited duty for injury.[27] While studies in training and garrison show that female soldiers suffer more limited duty days than men, it is unknown what the effect of MSIs is on duty days in deployed women. It is known that MSIs, as opposed to illness, account for the most lost duty days during deployment, with studies of mixed sexes reporting 6 to 18 days of limited duty per MSI.[8,12,19] One of the greatest limitations of these studies is that their participants were mostly men with no subset analyses conducted for women. Thus, the effect of MSIs on lost or limited duty days in deployed women is also unknown.

Additionally, the activity most often associated with MSIs is also largely unknown in deployed women. British soldiers most often identify body armor, lifting, and physical training as the cause of their back injuries.[38] British female soldiers suffered back injuries from physical training, occupational tasks, and off duty activities such as sports at a significantly greater rate than men, they were almost five times more likely than men to be injured.[38] Physical training, mechanical work, airborne activity, and road marching were the leading causes of MSIs in U.S. Army women; while physical training, mechanical work, sports, and airborne activity were the leading causes in men.[27] Of the occupational tasks, load carriage (wearing heavy equipment) has been identified by service members (a mix of men and women) as a common cause of injury in deployed environments.[2,9,12] This may be a larger problem in deployed environments since physical tasks such as wearing loads are much more common than in the U.S.

Compared to all other health problems, MSIs cause the greatest reduction in combat readiness.[23] In a sample of over 3,000 service members (men and women), 42% of those injured had difficulty performing their duties due to MSI and 19% of those injured could not perform their job at all and had to be replaced by other personnel.[12] Additionally, 5% of injured soldiers missed a combat patrol due to MSI.[12] In a separate study, 21% of injured soldiers stated they had difficulty firing their weapon due to MSI.[2] Seventeen percent of 15,000 service members were unable to completely perform their jobs due to MSI.[9] Having less soldiers available to work or having functional limitations puts lives in danger in deployed environments and this does not go unnoticed by the soldiers. Twenty-five percent of soldiers believed unit effectiveness had been negatively affected by injury.[9] Because of the dire consequences, possible death and failure to accomplish the mission, MSIs in deployed female soldiers can have a more detrimental affect than MSIs occurring in the U.S.

Musculoskeletal injuries are adversely affecting soldiers' health and their ability to effectively perform their duties as well as impacting their ability to protect themselves and others while deployed to combat zones. By identifying what types of MSIs are occurring in women, effective injury prevention programs can be developed to reduce MSIs and consequently decrease medical costs and discharges while increasing manpower and morale.[23] This study proposed to characterize MSIs sustained by female soldiers in brigade combat teams (BCTs) deployed to Afghanistan for nine months. Specifically, the purpose of this study was to describe the number of MSIs, their anatomical region, self-reported cause of MSI, timing of their occurrence, and the effect of MSI on lost/limited duty days and limitations to physical training and occupational tasks. It was hypothesized that the most commonly injured anatomical region would be the low back, the most commonly self-reported cause of injury would be lifting and carrying for work, and most injuries would occur during the first three months of the deployment.

2.3 METHODS

2.3.1 Study Design and Participants

This was a prospective cohort study. Three BCTs deploying to Afghanistan for nine month during 2012 were recruited for this study. These three brigades (groups) were differentiated by color coding (Red BCT, White BCT, Blue BCT, Table 1). Female soldiers assigned to a BCT with the intention of being deployed for the entire deployment period were invited to participate in the study. Soldiers were excluded if they knew beforehand that they would not complete the deployment due to leaving the Army, moving to a new unit, or retirement. This study was approved by the institutional review boards of the University of Pittsburgh and the U.S. Army Research Institute of Environmental Medicine. All eligible women were briefed on the study and consented prior to any research activities.

2.3.2 Procedures

Pre-deployment data collection took place up to eight weeks prior to deployment. Soldiers were asked to complete a survey regarding demographics based on a survey previously used by the U.S. Army Research Institute of Environmental Medicine (Appendix A, Table 1).[134,135] Height and weight was measured by research staff using a calibrated scale. Within four weeks of returning from deployment, the soldiers were asked to complete a second survey focusing on occupational activities and detailed injury information (Appendix A).[134,135] The survey collected information on type of body armor, work location, occupation, body region injured, duration of the MSI, limitations to physical training and occupational tasks, activity associated with injury, and month in which the MSI occurred.

The primary outcome variable of the study was MSI. A MSI was defined as any injury to muscle, tendon, bone, ligament, nerve, or joint that resulted in intermittent pain lasting for at least twenty-four hours which limited the soldier's ability to perform her occupational tasks or physical training.[124] Furthermore, the injury must be a new injury or recurrence of a completely healed injury (participant had no pain and no negative effects on ability to perform occupational tasks before deploying). Limitations to physical training or occupational tasks were categorized as "a lot, moderate, a little, and none."

2.3.3 Statistical Analysis

Cumulative incidence rate was calculated as the ratio of the number of participants suffering a new or recurrent MSI compared to the total number of participants over nine months. Incidence was calculated as the number of injured female soldiers divided by the number of total injury free months of deployment. Musculoskeletal injury was described as a percentage of the total for body region injured and reported activity associated with injury. The number of MSIs in each body region was divided by the total number of injuries in order to obtain the percent of MSIs occurring in each region such as the low back. The number of MSIs associated with each activity was divided by the total number of injuries to obtain the percent of MSIs occurring during each activity such as running. A single variable chi square test for goodness of fit was then performed to assess if there were significant differences in frequencies between the categories (body regions and activities) as well as the frequency of MSI occurring in each month of deployment. Pairwise comparisons were then performed to assess where any differences lie. For all analysis conducted, the alpha level was set at 0.05.

2.4 RESULTS

A total of 262 women were briefed on the study. Of those, 235 chose to participate in the study and completed the survey prior to deployment, Figure 1. Only 167 of these women deployed and 160 completed the post deployment survey. The seven who did not complete the survey returned home after the onsite investigator had left and did not respond to email.

The demographic characteristics of the 160 participants are shown in Table 1. In general, they were in good health, non-smokers, fit, and had normal BMI. The majority was single, sergeant rank, and had completed at least some college courses. The deployments lasted for an average of nine months with the average woman working seven days a week. The 160 women were deployed for a total of 1,296 months. They wore three different types of body armor; ninety-two (57.5%) wore the improved outer tactical vest (IOTV), 58 (36.3%) wore a plate carrier, and 10 (6.3%) wore the female IOTV. Most women worked indoors during deployment (Table 3) and 32.5% had physically demanding occupations. Most women worked in administration, 27%, while only 3% were mechanics (Figure 5). Thirty-nine women, 24.4%, were part of a Female Engagement Team (these are women who go on combat patrols with the men).

Of the 160 women, 57 (35.63%) suffered a combined total of 78 MSIs during deployment. Injuries appear to have had a greater impact on physical training than occupational demands such as working at a desk or in the supply yard, Table 4. Nine women could not perform their job at all and had to be replaced. The MSIs resulted in either impaired work or physical training for a combined total of 1642 days of limited duty, indicating an average of 21 (standard deviation=36) days per injury. The median number of limited duty days was 7 (interquartile range=30). Using the number of months prior to the first injury to calculate incidence, there were 5.2 injuries per 100 person-months. Given that the average woman worked 7 days a week, 9.6% of the available duty time was lost to MSI.

Fifty-four injuries (70%) were new MSIs and twenty-four injuries (30%) were injuries that had healed before deployment but were re-injured during deployment. Five subjects did not list the length of their injury. Most injuries resolved within 3 weeks, Table 5. The most injuries occurred prior to the fourth month (21) but there was no significant difference in the number of injuries that happened in each month $\chi^2(8) = 14.071$, $p = 0.080$, Figure 6. If the deployment was split into trimesters there was still no significant difference in the frequency of injuries occurring in each trimester $\chi^2(2) = 2.632$, $p = 0.268$.

Most injuries were to the knee, Figure 7. There was a significant difference in the frequencies of body region injured $\chi^2(10) = 40.462$, $p < 0.001$. It was hypothesized that the lower back would be the most commonly injured body region. However, results indicated the knee (24%) as the most commonly injured body region but there was no significant difference in the frequency of knee injury versus lower back injury (18%) $\chi^2(1) = 0.758$, $p = 0.384$. There was a significant difference in the frequencies of activity associated with MSI, $\chi^2(8) = 32.538$, $p < 0.001$. Most MSIs were associated with physical training, Figure 8. Contrary to the hypothesis, there were significantly more injuries due to physical training than lifting and carrying (12%), $\chi^2(1) = 4.8$, $p = 0.028$.

2.5 DISCUSSION

This is the first known study to investigate MSIs in deployed women. This study found that over a nine month deployment to Afghanistan, 35.6% of the deployed women were injured to such a degree that it caused limitations to either their physical training or occupational tasks. These injuries resulted in an average of 21 days of limited duty per injury. Most of these injuries (23%) were to the knee. The soldiers reported that physical training had led to most of these injuries, (31%). These limitations and lost duty days highlight the negative impact of MSIs on women while deployed and by extension, the size and readiness of our military power. Intervention programs targeting knee injuries and physical training could reduce the number of MSIs in deployed female soldiers, which in turn would increase available manpower.

The injury rate of 35.63% is slightly lower than that found in previous studies on female military members using a similar case definition, limitation to physical training or occupational tasks, (41% to 64%).[13,14,27,63] Three of these four studies were done on new soldiers in basic training. Soldiers in basic training are generally not as physically fit as regular Army soldiers.[156] Soldiers in training perform structured physical training and occupational training. In contrast, deployed soldiers can often choose physical training activities and have different physical occupational demands than those in training. Lower fitness levels, different physical demands and decreases in control during training may have resulted in higher injury incidence rates in training units than the current study. The fourth study was conducted with soldiers permanently stationed at Fort Bragg (not in training) and reported an injury rate of 51%.[27] This study differed from the current study in that it included only mechanics while the current study investigated the wide range of Military Occupational Specialty (MOS) found in brigades. Different MOSs have different occupational demands.[126,157] It is likely that the sample of mechanics had a higher incidence of injury than our study sample because they had higher physical demand. Mechanics are required to perform more physically demanding tasks than administrative workers.[157] Our sample had 43 (27%) administration workers and only 5 (3%) mechanics.

In addition to the difference in injury rates between deployed women and women in training, there is a difference in injury rates between men and women as well. Studies in basic training populations have shown that 45% to 57% of women sustained a MSI whereas only 27% to 46% of men did.[13-15] Injury rates are different in men and women in basic training and it stands to reason they would be different in deployed environments too. The incidence rates of MSI in deployed environments range from 16% to 35% in mostly male samples.[9,11,12] Given that research suggests men are less likely than women to suffer a MSI injury, it follows that the heavily male samples resulted in lower incidence of MSI than the 35% injury rate this study found in deployed women. The MSI incidence rate found in deployed women is lower than those in training and mechanics but higher than that found in mostly male samples of deployed service members.

These MSI can then be further divided into anatomical region injured. In the current study, 23% of injuries were to the knee while 21% were to the low back which differs from other studies reporting that the low back was the most frequently injured body region military wide and in deployed environments.[2,12,18-20,54,158,159] However, these studies were all dominated by men. Deployed soldiers are exposed to multiple physical stressors including occupational activities such as lifting and carrying equipment, patrols wearing heavy loads, working in awkward positions, and convoy operations (driving or riding in vehicles for hours while wearing combat equipment). Male and female soldiers may not be equally distributed among these physically demanding jobs. In a prior study investigating a BCT deployed to Afghanistan, 83% of male soldiers and only 66% of female soldiers were engaged in physically demanding jobs.[160] In the current study only 32.5% of female soldiers had physically demanding jobs. This could account for why the low back was the most commonly injured body region in the male dominated studies as opposed to the knee. Wearing equipment, lifting, and carrying are all risk factors for low back pain and found more often in the physically demanding jobs all of which are more highly populated by men.[2,9,12] In studies during training, the ankle was the most commonly injured body region with the knee often being a close second. The knee accounted for 11%, 28%, 7.4%, and 19% of the injuries in basic training studies.[28,63,125,161] The study on regular garrison mechanics at Fort Bragg found that most injuries in women occurred to the knee.[27] Based on our data and these previous studies, the injuries in deployed women are most similar to the mechanics. The deployed women in the current study were in the same environment as men but suffered primarily MSIs to the knee similar to the female mechanics and not low back injuries as the deployed men suffered. This suggests sex may be a better predictor than environment regarding the body region injured.

It was also shown that female athletes are at increased risk of knee injury compared to male athletes.[162,163] Anatomical and physiological differences between the sexes have been attributed as the cause for the higher rate of knee injuries in women.[163] Differences in joint laxity, pelvic geometry, lower limb alignment, and intercondylar notch width have all been suggested as the cause of the increased risk of knee injury.[163] Additionally, differences in jumping and landing patterns have also been identified as possible mechanisms of injury. The combination of less physically demanding work than their male counterparts and their predisposition to knee injuries, likely combined to result in the knee being the most commonly injured in deployed women. Programs designed to increase strength and proprioception while also providing instruction on jumping and landing technique have significantly reduced the number of knee injuries in female athletes.[163,164] Incorporating proprioceptive and strength training into military physical training may potentially decrease knee injuries in women despite the fact that most of the women were in administrative positions. These women still had to participate in daily physical training (which includes jumping and landing) and move about on uneven terrain.

In this study, physical training was the most common self-reported cause of MSI. Physical training has been labeled the activity most often associated with injury and the first priority for injury intervention programs in the military.[165] Research studies during basic training have investigated the effect of different physical training elements on injury rates. Running was associated with most physical training injuries during basic training (62% of male physical training injuries and 50% of female).[35-37] A prevention program reducing running mileage led to 10-24% less injuries while maintaining the soldier's running speed and saved $4.5 million in healthcare costs.[35-37,166] The current study did not separate running from physical training. It is possible that running is the aspect of physical training that led soldiers to believe it caused their injury. Future studies should look at different aspects of physical training such as duration, intensity, and type of exercise. Once elements of physical training have been identified as leading to injury, steps can be taken to reduce MSIs. This could lead to developing a prevention program for deployed soldiers such as the reduction in running mileage used in basic training.

Tripping or falling was the second most common self-reported cause of injury, 17%. This is similar to studies on other military populations. In a study over a 12 month deployment to Afghanistan, tripping or falling accounted for 8% of injuries.[167] Slips, trips, or falls were the most common cause of injury on aircraft carriers.[168] In the U.S. Air Force, the leading cause of lost work days was slips, trips, or falls, 12%.[169] Traversing uneven terrain was cited as the cause of 7% of injuries in a deployed records review of physical therapy patients.[20] The terrain on and off the base when deployed is often uneven. It is rare to find asphalt or concrete on deployed bases. Most pathways on Afghanistan bases are either covered with rocks or dirt. Additionally, soldiers are climbing in and out of vehicles and aircrafts often while wearing 40 lbs. of equipment. All of these factors could explain why trips and falls are such a problem. Possibly creating a boot with increased ankle support or increasing lower extremity proprioceptive training could reduce the number of injuries due to trips or falls. Very limited proprioceptive training is currently performed during physical training. Proprioceptive training has resulted in a significant decrease in ankle injuries both for those with a history of ankle sprains and those without a history of ankle sprains and might help reduce trips and falls in the military as well.[170-173]

Lifting and carrying was the self-reported cause of 15% of MSIs in the current study. Lifting and carrying was the primary cause for injury in another study on deployed service members as well; 9.8% of injuries were associate with lifting and carrying.[167] Lifting and carrying was the third most common cause for lost duty days in the U.S. Air Force, 2%.[169]
Cohen et al. found that lifting objects (18%), falls (11%), and driving (8%) were the most common mechanisms of injury in patients medically evacuated for low back pain.[5] Lifting has also been identified as a risk factor for low back pain in industry.[51] Lifting heavy weights, those over National Institute for Occupational Safety and Health recommendations, have been shown to be a risk factor for injury.[53,58] Repetitive lifting has also been identified as a risk factor.[174]

Teaching the soldiers to lift more ergonomically may reduce injury. As far as prevention there are some simple strategies to reduce injury. The object should be as close to the feet as possible before beginning to lift.[175] The feet should be beside the object being lifted and not behind it.[176] All lifts should be done symmetrically.[177] The back should not be bent more than 60º or rotated more than 30º.[178] Loading is also less when stoop lifting is used compared to squat lifting.[176] Currently soldiers receive little to no ergonomic training. Introducing such training, especially to military occupational specialties that perform a great deal of lifting, could reduce the number of injuries occurring due to lifting objects.

The current study found that the average time of limited duty per injury was 21 days. This is slightly higher than that found in previous research. The average MSI in male infantry soldiers resulted in 16 days of limited duty.[25] In surveyed deployed soldiers, the average number of limited duty days per injury was six days.[12] The average number of days of limited duty in female mechanics at Fort Bragg was 12.6.[27] It is possible that the current study had a higher number of limited duty days because limited duty days were included in the definition of MSI while the other studies cited here did not include limitation to duty in their definition of injury. By including less severe injuries, those not resulting in limited duty, the other studies are dividing the number of limited duty days by all injuries and not just the more severe injuries as was done in the current study. This resulted in less limited duty days per injury in those studies compared to ours. In two basic training study using the same definition of injury as the current study, the average number of days of limited duty for females was 9.6 and 8.5.[14,63] These numbers did not include the limited duty time of over 100 females who did not finish basic training due to injury. [14,26] This would result in a lower average limited duty days because the total number of days was not used. The current study shows the importance of including these more severe injuries to get a more accurate limited duty rate. Thirty-five percent of the women in this study were on limited duty for 7.8% of the deployment. This was 9.6% of the available female soldier duty time.

Although there was no significant difference between the proportions of injuries occurring in each month, there was a large spike at month three and then a downward trend (Figure 2). Occurrence of injury appears to be more common in the first half of the deployment than the second half. No other study to date has looked at the distribution of injuries across the deployment. However, this has been looked at in Marine Officer Training, where the most injuries occurred during weeks 2, 3, and 6.[179] In enlisted Marines, most injuries occurred during weeks 3, 8, 10, and 11 of the 12 weeks of basic training.[125] It is possible that the trend of most injuries occurring in the beginning of longer deployments, is due to soldiers first needing to acclimate to the change in physical demands and once this acclimation is achieved, the number of injuries decrease. The change in physical demands is likely greater between civilian life and joining the Marine Corps than between being stationed in garrison versus being deployed. Soldiers train more to prepare for deployment than civilians entering the service. This increase in training may act as a protective factor during the initial acclimation phase and explain why a spike in injuries is not observed until month three. Additionally, most injuries are a result of overuse as opposed to an acute incident and thus require time to develop.[125] Therefore, gradually increasing training in deployed tasks at least three month prior to deployment may reduce the number of injuries occurring during deployment. A gradual increase in difficulty of tasks may reduce the chance of an overuse injury and help all soldiers to get used to the increase in demands before deploying.

2.5.1 Conclusion

Musculoskeletal injuries affect deployed female soldiers more (35%) than deployed male soldiers (16%).[11] Injury prevention programs for female soldiers should target knee and low back injuries. A more thorough investigation of physical training needs to be done in regular Army units to identify what part of physical training is leading to these injuries. Finally, injury prevention programs shown to decrease trips and falls should be investigated for use in the Army.

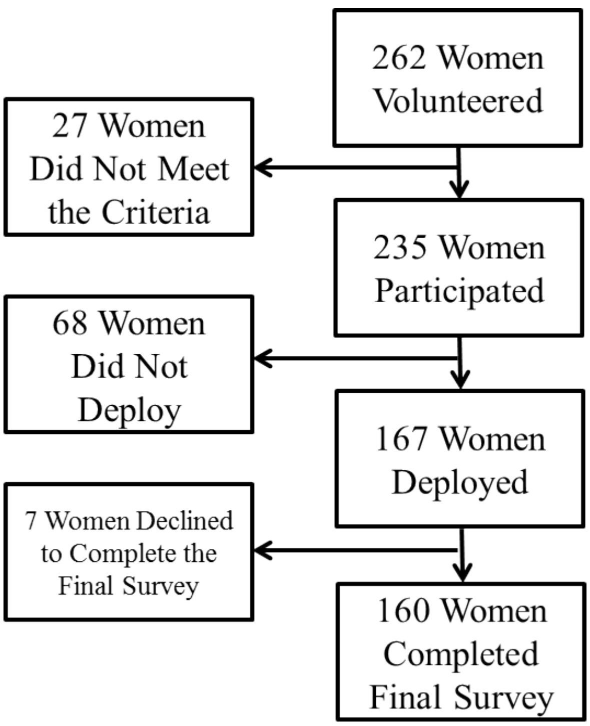

Figure 4. Participant Flow Chart

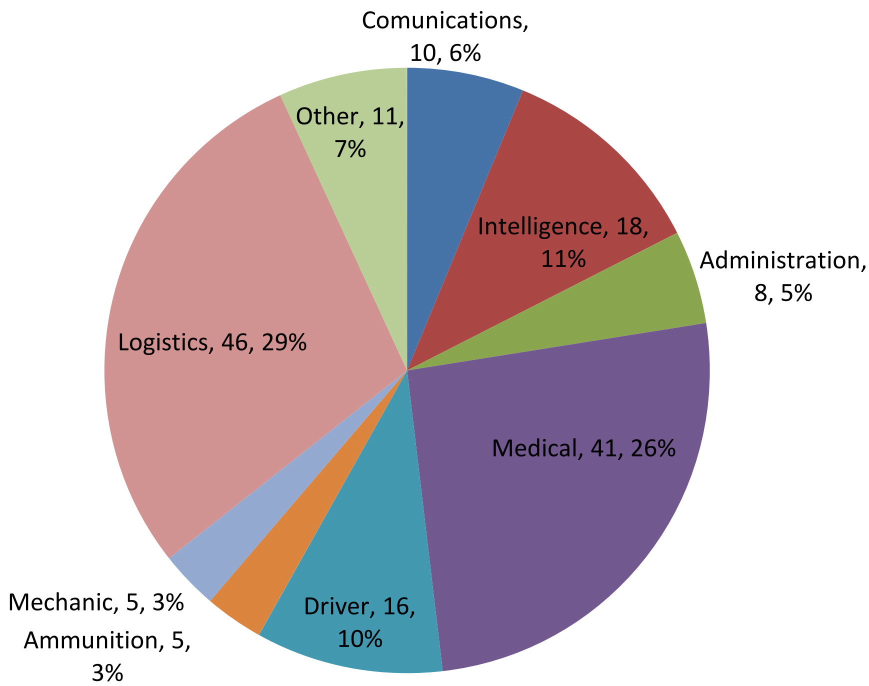

Figure 5. Occupations

Table 3. Sample Characteristics

Variable	**N**	**Percent**
Marital Status		
Single	77	48.1%
Married	65	40.6%
Divorced	18	11.3%
Family Size		
No spouse/children	103	64.4%
1 family member	40	25%
2 family members	7	4.4%
3 family members	5	3.1%
4 or more family members	5	3.1%
Self-reported Health Status		
Excellent	44	27.5%
Good	95	59.4%
Fair	20	12.5%
Poor	1	0.6%
Smoker	47	29.4%

Table 3. (continued)

Highest Education		
High School	34	21%
Some College	80	50%
Bachelor's Degree	40	25%
Master's Degree	6	4%
Brigade Combat Team		
Red brigade	74	46%
White brigade	63	39%
Blue brigade	23	15%
Main Duty		
Working Indoors	108	67.5%
Lifting and Carrying	19	12%
Mechanic	3	2%
Riding in Vehicles	7	4%
Working off the FOB**	20	12.5%
Guard Detail	3	2%
Variable	**Median**	**Inter Quartile Range**
Age	25.0	6.0
Rank	E5*	2.0
Height (cm)	160.0	7.6
Weight (kg)	66.3	14.2
Body Mass Index (kg/m^2)	25.0	4.1
Army Physical Fitness Test	270.0	44.0
Number of Months Deployed	9.0	1.0
Days Worked per Week	7.00	2.0
Number of Previous Deployments	0	1.0

*Enlisted level 5, Sergeant

** FOB – Forward operating base

Table 4. Musculoskeletal Injuries with Limitations

Limitations to:		N	%
Physical Training	None	5	7%
	A Little	23	29%
	Moderate	21	27%
	A Lot	29	37%
Occupational Tasks	None	19	24%
	A Little	36	46%
	Moderate	20	26%
	A Lot	3	4%

Table 5. Duration of the Musculoskeletal Injury

Length of Injury	**N**	**%**
Less than 1 Week	3	4%
1-3 Weeks	27	37%
1-3 Months	15	20.5%
4-6 Months	13	18%
7-9 Months	15	20.5%
Total	73	100%

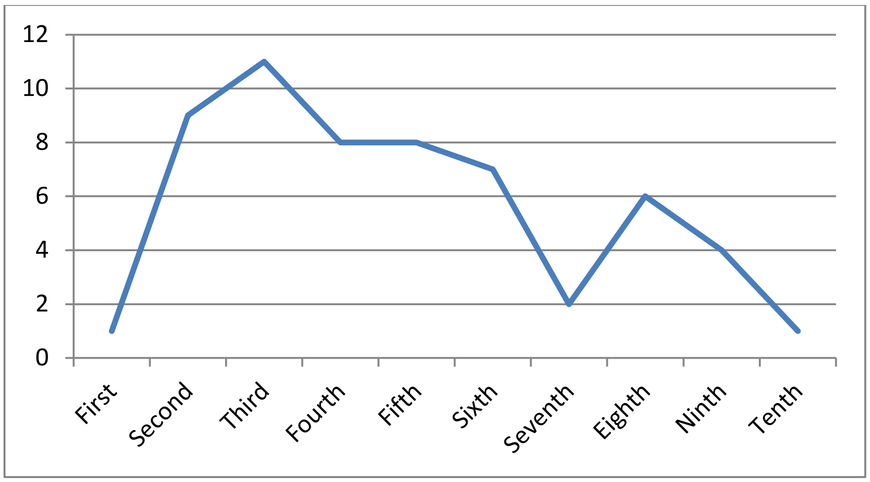

Figure 6. Month of First Injury

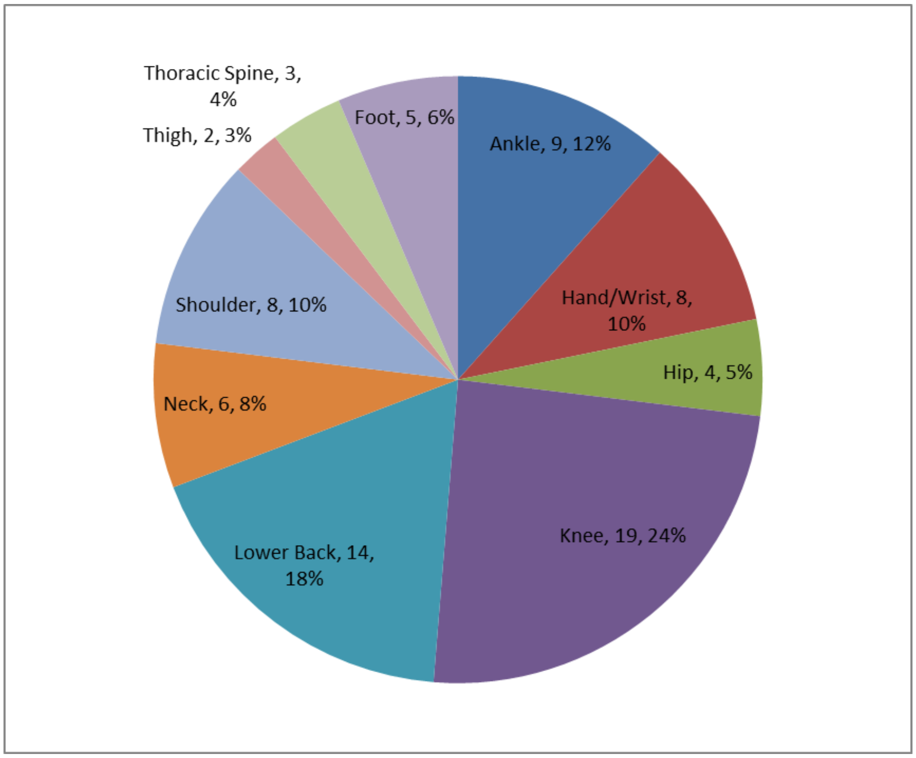

Figure 7. Anatomical Regions Injured (N=78)

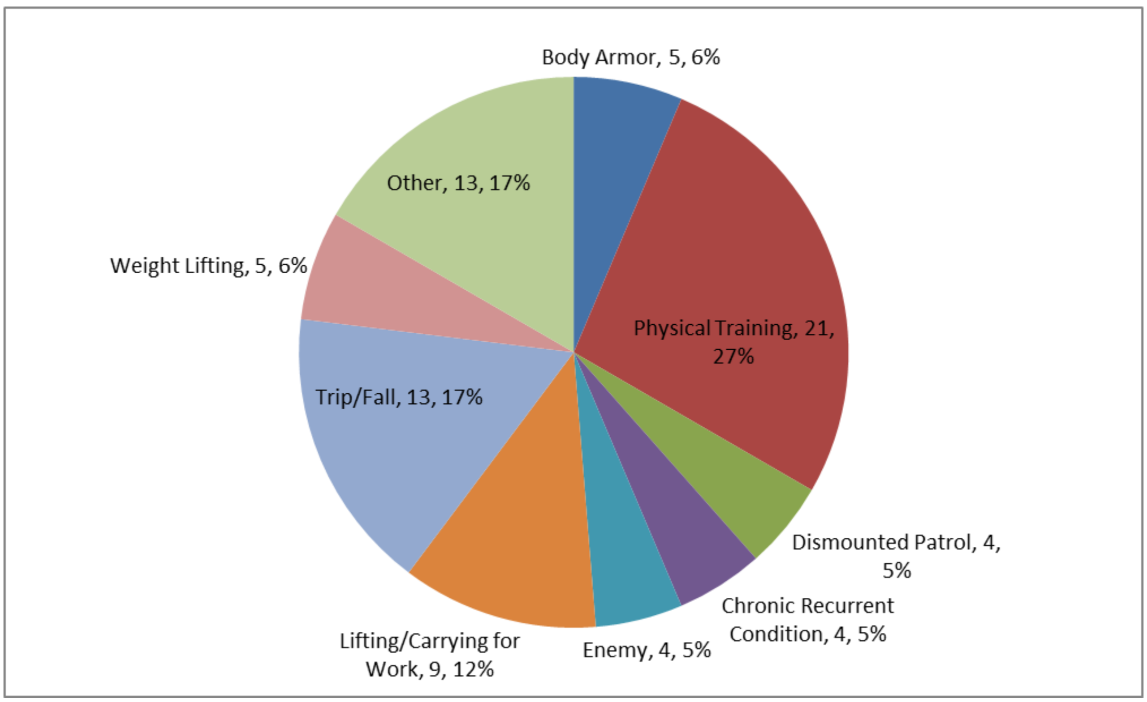

Figure 8. Self-reported Cause of Musculoskeletal Injuries (N=78)

3.0 RISK FACTORS FOR MUSCULOSKELETAL INJURIES IN DEPLOYED FEMALE SOLDIERS

3.1 SUMMARY

Up to 70% of deployed service members suffer a musculoskeletal injury (MSI) during deployment. Each year injuries result in millions of lost duty days and billions of dollars in disability costs. With such high costs and so many service members being affected, identifying risk factors contributing to these injuries is of critical importance. Accordingly, the purpose of this prospective cohort study was to investigate occupational, physical, and psychosocial risk factors for MSI in female soldiers. Female participants were recruited from three brigade combat teams deploying during 2012. Prior to deployment, participants underwent performance testing and completed several surveys collecting demographic information as well as measuring levels of coping ability, sleep, and job stress. Upon completion of the deployment, soldiers filled out surveys including an additional survey on occupational demands and MSI. Results of these surveys indicated that of the 160 women participating in the study, 57 (36%) suffered 78 MSIs. In unadjusted analyses the following factors increased the relative risk (RR, 95% Confidence Interval (CI)) of injury: wearing an average load greater than 10% of body weight (RR=2.00, 1.31-4.57), wearing an average load longer than one hour (RR=2.44, 1.30-4.57), wearing the heaviest load more than 15% of body weight (RR=5.83, 1.51-22.50), wearing a backpack

(RR=1.82, 1.23-2.80), wearing body armor longer than an hour (RR=1.62, 1.002-2.62), lifting objects weighing over 22.68 kg (RR=1.96, 1.08-3.57), lifting objects 1-2 times (RR=1.73, 1.002-2.97), carrying objects more than 7.62 m (RR=2.01, 1.19-3.42), and Y balance composite score less than 95.23 (RR=1.71, 1.13-2.60). In the most parsimonious logistic regression model, an average load greater than 10% of body weight (OR=1.04, 1.01-1.07), the heaviest load calculated as a percent of body weight (OR=1.03, 1.01-1.05), the average number of repetitions of lifting an object (OR=1.07, 1.01-1.14), and sit ups during the Army Physical Fitness Test (OR=0.93, 0.93-0.99) were the set of variables that best predicted MSI while controlling for brigade and number of family members. Results of this study suggest that training to improve load bearing ability, lifting endurance, and core strength should be considered to decrease MSI in deployed female soldiers.

3.2 INTRODUCTION

With conflicts in Iraq and Afghanistan occurring simultaneously, U.S. Army soldiers are spending more time in combat zones.[1] This increased operational tempo has resulted in an unknown change in physical demands on the soldier, which in turn, can affect the risk of injury.[2] Currently, musculoskeletal injuries (MSIs) account for at least twice as many medical evacuations as combat injuries.[3-5] Musculoskeletal injuries are also the leading cause of ambulatory medical visits, both in garrison (home base) and while deployed to combat zones.[6-10] In non-deployed samples, women suffered more injuries and more severe injuries than men.[13-15] Research showed that the injuries themselves are different. [15,24] Both men and women have ankle injuries but men have more low back pain and women more knee pain.[14,24] These MSIs are costly in terms of lost duty days, medical expenses, evacuations, and medical discharges from military service. Musculoskeletal injuries reduce manpower and combat strength, decrease morale, and threaten overall mission accomplishment.

According to the U.S. Army Public Health Command, there are five steps to successful injury prevention: surveillance, injury prevention, effectiveness of intervention, program an policy implementation, and evaluation of programs and policies.[23] In order to effectively prevent injuries in deployed women, the first two steps of injury prevention must be accomplished followed by steps three through five. The proposed study will address both steps one and two.

Surveillance, the initial step of prevention, involves identifying injuries. Studies investigating the incidence rate of MSI on service members in garrison found that women have a higher incidence rate of MSIs (45% to 57%) than men (27% to 46%).[13-15] There are also two studies of male dominated deployed populations reporting MSI incidence rates of 20% and

35%.[9,12] However, both studies used samples that were at least 90% male with no subset analysis performed on female soldiers leading to the results being driven by the men.[2,9,11,12] Thus far, only one study has identified the rate of MSI in *deployed* women. This study identified the rate of MSI in deployed women to be 50%; however, this study was limited due to the comparatively small number of female participants (8%) and the information on MSI was collected through inaccurate electronic records.[11] MSI effect women in garrison more than men but their effect on deployed female soldiers is largely unknown.

The second step is injury prevention and this starts with research on risk factors and mechanisms of injury. To date, there has been no known research conducted on risk factors for MSIs in deployed women. Risk factors, especially physical risk factors, for MSIs have been more extensively researched in garrison military populations, mostly basic training and are often different in women than men.[16] Lower fitness before basic training, fewer sit ups, and low flexibility were risk factors for men but not women.[63] A separate study showed that shorter height was a risk factor for women whereas higher body mass index was a risk factor for men.[14] Physical training, mechanical work, airborne activity, road marching, and garrison activities were the leading causes of injury in women; while physical training, mechanical work, sports, and airborne activity were the leading causes in men.[27] Results from these studies in training military populations may not be applicable to professional soldiers as deployed soldiers are fitter, older, and operate in a different environment.

To date, although no studies have investigated risk factors for women in deployed environments, there are some with mixed samples, predominantly male. These studies have described occupational factors as self-reported cause of injury. Heavy gear/lifting was identified as the second most frequent perceived cause of MSIs in the study of over 3,000 service members.[12] Another study of over 15,000 service members found similar results with heavy loads leading to 14% of injuries.[9] Of 863 surveyed soldiers in Iraq, 30% felt that body armor caused their injury. [2] While these studies described the occupational self-reported causes of MSI, they did not investigate if the actual exposures were statistically associated with MSI. Additionally, 90% of the sample was male.

Finally, in civilian studies psychosocial risk factors including disruptions in sleep, increases in job stress, and less coping ability have all been identified as risk factors for injury. [90-93] None of these psychosocial factors have been investigated as risk factors for injury in military populations.

By identifying accurate incidence rates and physical, occupational, and psychosocial risk factors for MSIs, prevention programs can be developed to address these factors. By addressing the risk factors individually in soldiers, the number of MSIs may be reduced. In turn, this would reduce the days of lost duty as well as the number of musculoskeletal discharges in the U.S. Army, potentially saving billions of dollars. The purpose of this study was to describe the incidence of MSI and identify risk factors for MSI in female soldiers deployed to Afghanistan. Specifically, this study aimed first to determine the physical and occupational risk factors for MSIs in women assigned to a brigade combat team (BCT) deployed to Afghanistan, and second to determine the psychosocial risk factors for MSIs in women assigned to a BCT deployed to Afghanistan.

3.3 METHODS

This was a prospective cohort study that investigated risk factors for MSI in women deployed to Afghanistan. Three BCTs deploying to Afghanistan for nine months during 2012 were recruited for this study. The study was approved by the Institutional Review Boards of the University of Pittsburgh and the U.S. Army Research Institute of Environmental Medicine.
All female soldiers assigned to the three BCTs with the intention of being deployed for the entire 9-month deployment were offered the opportunity to participate in the study.

3.3.1 Data Collection

Pre-deployment data collection took place up to eight weeks prior to deployment. Every attempt was made to keep pre-deployment data collection within four weeks of deployment.

Prior to deployment, all the women were briefed on the study and those who volunteered were consented to participate in the study. After being consented, the women participated in pre-deployment testing involving surveys, height and weight measurement, and performance testing. Post-deployment data collection was done within eight weeks of the soldier's arrival back to her home base and the majority were done within the first two weeks.

The primary outcome variable was self-reported MSI collected in the post deployment survey. A MSI was defined as injury to muscle, tendon, bone, ligament, nerve, or joint that results in intermittent pain lasting for at least twenty-four hours which impairs the soldier's ability to perform her occupational tasks or physical training.[124] The MSIs had to be new injuries or the recurrence of a completely healed injury. An injury was considered previously healed if the participant experienced no pain and no negative effects as a result of the injury on her ability to perform occupational or fitness tasks before deploying. Injuries that participants had at the time of deployment were not included in calculations.

3.3.2 Potential Risk Factors

Height and weight were measured by research staff using a calibrated scale and a stadiometer. Physical ability was measured by participants' scores for the Army Physical Fitness Test (APFT), Y Balance Test, Illinois Agility Test, and Weighted Step Test. The APFT measures the soldiers' upper and lower body muscular endurance.[126] The APFT includes in order, two minutes of push-ups, two minutes of sit ups, and a two mile run. The Y Balance Test is a dynamic balance test performed while standing on one leg.[75] The Illinois Agility Test measures agility by combining sprinting with changes in direction. [90,91] Prior to deployment, the soldiers provided information on demographics, injury history, and occupation by completing the Afghanistan Activity and Injury Survey (Appendix A) (a modified version of a previously used survey from the U.S. Army Research Institute of Environmental Medicine).[134,135] The Post-Deployment Afghanistan Activity and Injury Survey was administered after deployment to collect injury information and occupational activity levels during deployment (Appendix A). [134,135] Occupational risk factors in this survey included type of occupation, average time wearing body armor, average time standing, distance walked, weight of average load worn, heaviest load worn, days per week performing lifting tasks, average weight of objects lifted, average times the object was lifted per day, average height objects were lifted from, and the average height to which the objects were lifted.[134,135]

Potential psychosocial risk factors included coping ability, sleep, and job stress measured pre and post deployment by the following surveys. The Pittsburgh Sleep Quality Index (PSQI) is a self-administered questionnaire that was used to provide a quantitative measure of sleep quality over the past month (Appendix B). [136] The Job Content Questionnaire – 14 (JCQ), a psychosocial job assessment questionnaire, was used to measure job stress (Appendix C),[138-142] Coping was measured using the Brief COPE, a self-administered questionnaire designed to quantify a participant's ability to cope (Appendix D). Additionally, the PSQI, the JCQ – 14, and the Brief COPE were administered post deployment but solicited information during deployment prior to the soldier becoming injured.

3.3.3 Statistical Analysis

For sample size estimation, we used a conservative 30% rate of injury based on previous studies. [2,9,11] Approximately 10 injured participants were necessary to supply statistical power for each variable entered into the logistic regression. Assuming there were four variables in the logistic regressions a sample size of 133 would be required to have 80% power. Additionally, a sample of 133 would also allow detecting a difference in injury of 23-26% assuming that the ratio of exposed to non-exposed varies between 0.35 and 1.30. Estimating a dropout rate of 25%, the recruitment target was 177 women.

Self-reported incidence of MSI was the dependent variable (outcome) for all analyses. The incidence rate of MSIs was calculated as the ratio of the number of participants suffering a new MSI to the total number of participants. Analyses for risk factors were then performed in three steps. Step 1 consisted of univariate associations between each potential risk factor and the outcome. Continuous variables were analyzed using independent sample t-tests of each dependent variable with two groups: injured and non-injured. If they were not normally distributed, the Mann-Whitney U test was used. Categorical variables were analyzed with the chi-square test of independence. Any demographic variables that were significantly different between the two groups were controlled for in future multivariable calculations.

Step 2 consisted of the calculation of relative risk (RR) and 95% confidence intervals (CI) for all variables. Continuous variables were organized into categorical data based on previously published functional levels of each variable. If no functional level existed then the data was split at the 35% percentile. The RR was calculated as the ratio of the incidence of injury in the exposed group divided by the incidence of injury in the unexposed group.[150] RR is the likelihood that someone who has been exposed to the risk factor will become injured.

Step 3 consisted of establishing the most parsimonious set of predictors of MSI. For this step we used logistic regression adjusted for brigade and any demographic variable associated with MSI. Variables found to have an association with MSI with a p-value < 0.1 (and not highly correlated to another dependent variable) during step 1, or a significant increase in risk during step 2, were considered for the simultaneous logistic regression. If only the relative risk was significant, the variable was input into the regression in the dichotomous form used to calculate the relative risk. Hierarchical modeling approach with all subset method of model building was used splitting risk factors into physical, occupational and psychosocial variables. Variables related to MSI at the $p<0.1$ were entered into the models. Model building first used the set of physical and occupational variables only. This was followed by model building with the psychosocial variables only. Finally, model building was conducted using physical, occupational, and psychosocial variables together. For these, the equation with the lowest

Akaike Information Criterion (AIC) and the highest area under the curve (AUC) in the Receiver Operator Curve (ROC) was selected. The AIC is a measure of goodness of fit that identifies the best fitting model with the least complexity while being the criterion least affected by degrees of freedom.[180] The AUC for this model was then calculated. Next the variables (coefficients) that were not significant in the model were removed and the AUC for the now smaller model was found. The two AUCs were compared to discover if they were significantly different.[181] The result was the most parsimonious model predicting MSI. For the final model investigating all variables, ROC curves were calculated for the predictors that significantly increase the odds of MSI.

Exploratory analyses were done to assess the best cut off values for those variables in the final logistic regression model using Youden's Index. Additionally, two logistic regression models were used to assess for possible moderations. A logistic regression was used to test if the type of body armor was a moderator for time spent wearing body armor because the participants wore two different types of body armor.

3.4 RESULTS

Of the 262 women briefed on the study, 235 chose to participate and completed the surveys prior to deployment, as seen in Figure 9. Of the 167 women who deployed, 160 completed the post deployment survey. Seven women chose not respond to email requests to complete the surveys. Sample characteristics can be found in Table 6. Of the 160 women surveyed, 57 (36%) suffered 78 injuries that resulted in either impaired work or physical training for a combined total of

1,642 days of limited duty, and an average of 21 days/injury. The range of the number of deployments completed by participants was 0-3.

The median BMI was 25 kg/m2 (Q25 = 22.8 kg/m2; Q75 = 27.0 kg/m2) and 98% of the women completed over 45 sit ups (Table 6). The average APFT was 263 out of 300, which represents good fitness. Less than 2% of the women ran slower than 19 minutes and 48 seconds and the average number of push-ups performed was 43 (minimum amount of push-ups done was 17). The average time for the Illinois Agility Test in this sample study was 21.5 seconds. Soldiers in the current study also had a median time of two hours a day of both standing and walking and walked a median of 3.2 km.

When using logistic regression to control for brigade, the number of family members was the only demographic variable significantly associated with MSI (p=0.04) and it was then controlled for in future multivariable analyses.

In unadjusted analyses injured soldiers reported more time spend wearing body armor and more time spent wearing a back pack (Table 7). Analyses controlling for design measures of brigade and number of family members found that injured soldiers reported doing less sit ups (Table 7). Both adjusted and unadjusted analyses found that injured soldiers reported more time spent wearing the average load, higher average load as percent of body weight, higher heaviest load as percent of body weight, more time wearing the heaviest load, higher average weight of lifted objects, higher average number of times an object was lifted, and higher average distance the object was carried. Average load worn was significantly higher in those injured compared to non-injured, p=0.001 (Data not reported in Table 7). Average load worn remained a predictor of injury when controlling for brigade and number of family members, p=0.001 (Data not reported in Table 7). The same was true for the heaviest load worn, it was significantly higher in those injured both unadjusted and adjusted, p=0.002 in both cases (Data not reported in Table 7). Average load and heaviest load worn as percent of body weight were used for the logistic regression and not the raw loads as they accounted for the load weight and the soldier's weight.

When relative risks were calculated, the best Y Balance composite score and height the object was lifted to significantly increase the risk of MSI (Table 8) but were not related to MSI in Table 2. There was a significant increase in risk for those wearing more than 29 lbs. (13.15 kg) compared to no weight, RR=2.05 (CI=1.387-4.511) (Data not reported in Table 8). There was also a significant increase in risk for those wearing a heaviest load greater than 48 lbs. (21.77 kg) compared to those wearing less than 48 lbs., RR =1.56 (CI=1.028-2.382) (Data not reported in Table 8).

Among the physical and occupational variables 13 met the criteria for entry into the logistic regression model. Those with injury did significantly less sit ups than those injured, p=0.048. There was a significant elevation in risk for those with a Y Balance composite best score of 95.2 or less compared to those scoring over 95.2, RR=1.7 95% CI 1.1-2.6. The following occupational variables differed between those injured and those without injury at the p<0.1 level: hours wearing body armor, hours wearing a backpack, average load worn as percent of body weight, time wearing the average load, heaviest load worn as percent of body weight, time wearing the heaviest load, number of days per week spent lifting, average weight of lifted objects, average number of times an object was lifted per day, and average distance an object was carried. Both the unadjusted results (MWU test, t-test, and RR) and the adjusted results had the same significant results with the exception of the Y Balance best composite and sit ups, supporting the robustness of the results.

Results from the all-subset method of model building using occupational and physical fitness variables indicated that the combination with the lowest AIC and highest ROC value was brigade, family members, average load as percent of body weight, heaviest load as percent of body weight, time spent wearing the heaviest load, average weight of objects lifted, the average number of times an object was lifted, the average distance an object carried, and sit ups, Table 9. Then those variables with non-significant odds ratios were removed and the AUC was found, AUC=0.80. The two AUCs (0.82 and 0.80) were compared and were not significantly different p=0.325. Therefore the more parsimonious set was selected and the results are found in Table 10. The Hosmer and Lemeshow test for this model was not significant demonstrating goodness of fit $\chi^2(8)=8.337$, p=0.401. Increasing the average load worn by 1% body weight increased the odds of MSI by 4.2%. Increasing the average load worn by 10% of the body weight increased the odds of MSI by 50.9% (1.042^{10}). Increasing the heaviest load by 1% of body weight increased the odds of MSI by 2.8%. Lifting objects more often was a predictor of MSI. Lifting objects an extra time increased the odds of MSI by 7.2%. Doing one more sit up on the APFT decreased the risk of MSI by 4%.

Results from the all-subset method of model building using only psychosocial variables indicated that only the deployment PSQI score and the pre-deployment Brief Cope Score were different between injured and healthy women at the $p<0.1$ level. The set with the combination of the lowest AIC and highest ROC value included PSQI score and pre-deployment Brief Cope score (Table 11). All variables remained in the equation although none of the odds ratios were significant, AUC=0.67. This model was compared to a model with just brigade and the number of family members, AUC=0.59, and the AUC of the two models was not significantly different, p=0.221. The more parsimonious model was selected, Table 12. The Hosmer and Lemeshow test was not significant $\chi^2(5)=5.521$, $p=0.356$. PSQI scores from post deployment and pre-deployment Brief Cope did not significantly improve the base model predicting MSI indicating that these psychological variables were not important in predicting MSI.

The final logistic regression model started with all variables (physical, occupational, and psychological) that were related to MSI at $p\leq0.10$. The set of variables with the combination of the lowest AIC and highest ROC value was brigade, family members, average load as percent of body weight, heaviest load as percent of body weight, time the heaviest load was worn for, the average distance an object was carried, sit ups, PSQI, and pre-deployment Brief Cope scores, AUC=0.82 (Table 13). This model was compared to a model with only the variables with significant coefficients, AUC=0.80, and the AUC of the two models were not significantly different, $p=0.305$. The more parsimonious model was selected, Table 14 (Hosmer and Lemeshow test, $\chi2(8)=8.337$, $p=0.401$).

In exploratory analysis, 98% completed more than 45 sit ups in two minutes. The AUC in the ROC curve for sit ups was 0.58 with 76.5 identified as the optimal cutpoint. The AUC for the average load was 0.65 with 6.2% identified as the optimal cutpoint. The AUC for the heaviest load was 0.65 with 25.8% identified as the cut off maximizing the sensitivity and specificity for identifying those that had MSI. The AUC for the average number of times an object was lifted was 0.59 with 11 times identified as the cut off maximizing the sensitivity and specificity for identifying those that had MSI. Two logistic regression models were used to assess for possible moderations. A logistic regression was used to test if the type of body armor was a moderator for time spent wearing body armor while controlling for brigade and number of family members. It was not, $p=0.644$.

3.5 DISCUSSION

This is the first known study focused on identifying risk factors for MSI in deployed female soldiers. With the military opening up combat oriented occupations to women, it is important to identify possible risk factors for MSIs in women in combat environments. This study found that the variables that best predicted MSI in female soldiers deployed to Afghanistan were higher average load and heaviest load as a percentage of the soldier's body weight, lifting objects for more repetitions, and performing fewer sit ups on the APFT while controlling for brigade and the number of family members. The psychosocial variables of sleep, coping, and work stress were not found to be risk factors for injury.

The present study has contributed a clearer understanding of the incidence rate of MSI for female soldiers deployed in Afghanistan (36%), thus satisfying step one. Furthermore, the present study identified three risk factors (average and heaviest load worn, number of repetitions for which an object was lifted, and one protective factor (sit ups), satisfying the requirements of step two. With the initial requirements of these steps met, it is now possible for efforts to be made to investigate potential prevention programs.

3.5.1 Load Carriage

Load carriage (wearing heavy equipment) has been perceived by soldiers as a cause of injury.[2,9,12] This is one occupational task that is required to work outside the base in combat zones. In the current study, the relative risk of MSI increased to 150% when the average load was greater than 13 kg in women. Only one previous study investigated the weight of worn equipment by deployed soldiers as a risk factor for injury.[160] This study had 588 participants, 9.7% were women and analysis combined the data of men and women. In that study, there was not an increase in risk until the average load was greater than 34 kg and the increase in risk was only 36%. In the current study, risk increased when the heaviest load was greater than 22 kg and increased 56%. In the previous study the risk increased when the weight surpassed 45 kg and increased 60%. One can see the difference in tolerance of weight worn between the all-female sample and the male dominated sample.

The same trend was noted when the weights are expressed as a percentage of the soldier's body weight. The average load worn in the previous study for women was 16% of their body weight, compared to that in the current study of 13%. In the previous study, the average load worn by the men was 26% of their body weight. In univariate analysis, both studies found that average loads greater than 10% body weight increased relative risk. Risk increased 100% in the current study and 30% in the previous male dominated sample. Only the current study found average load to be a risk factor for MSI and the odds of MSI increased 51% for a load that increased 10% of the soldier's body weight. Even in multivariate analysis the risk was still almost twice that of the male dominated study. For the heaviest load worn in the current study a 483% increase in risk with loads greater than 15% body weight can be observed. In the male dominated sample, risk did not increase until the heaviest load was at least 26% of body weight and risk only increased 72% at this level. In all cases, the risk was much less in the male dominated sample showing that the risk of the weight worn to cause MSI is higher for women. These data support that the difference in body weight between men and women is not responsible for the increased risk of MSI found in women wearing loads. The women in both studies are wearing loads accounting for lower percent body weights than the men yet the risk is still higher in women. Therefore, it is not the men's increased body weight that is protecting them from MSI risk. It could be the increased strength in men decreases MSI risk. A previous study showed that the speed women were able to run two miles with a load increased after strength training.[48] This shows that training can reduce the effect load has on a female soldier's ability to move with the load. No study has looked at the effect of strength training on injury but if tolerance of the load during movement can be improved MSI could be reduced. Future studies should look at whether leg and/or core muscle strength could protect against MSI from load carriage in female soldiers.

3.5.2 Occupational Lifting

While lifting tasks do not apply a constant load to the soldier as worn equipment does, they nonetheless increase stress on the body.[182] A study of a predominantly male population of 3,000 deployed military members found that lifting was one of the most commonly reported causes of injury in deployed soldiers.[12] The current study found that the average weight of objects lifted, the average number of times they were lifted, and the average distance the object was carried all increased the risk of injury. In multivariate analysis only the average number of times the object was lifted predicted injury. The repetitive motion of lifting seems to be more detrimental than the weight of the object or how far the object was carried after it was lifted. A previous study, on a deployed sample made up of less than 10% women, did not find repetitions of lifting to be associated with injury in univariate analysis but did find it to be significant in multivariate analysis.[160] In both studies this variable predicted MSI indicating that in both men and women lifting repetitions seem to be an important risk factor.

Studies in industry have also noted an increase in injury risk with repetitive lifting and others have reported and other have reported that there are negative changes in mechanical and neuromuscular properties of the spine during repetitive lifting involving spine flexion.[50-52,183] Decreasing the angle of trunk flexion and/or decreasing the rate of repetitions may both decrease the detrimental effects of repetitious lifting tasks.[184] One method of mitigating the risk with repetitive lifting might be to teach soldiers to limit trunk flexion during repetitive lifting which could potentially decrease the risk of injury. A second avenue for risk mitigation may be to use resistance training. A study on 13 female soldiers demonstrated that after 14 weeks of resistance training these soldiers significantly improved their ability to perform more lifting repetitions.[185] While this study did not investigate repetitive lifting as a risk factor for MSI, the fact that lifting repetitions increased in these soldiers makes it possible that the repetition threshold for lifting without risk for injury also might increase with training. This factor should continue to be investigated in future military studies in both men and women.

The current study found that lifting objects more than 23 kg increased the risk of MSI. This is in agreement with a previous study from industry which found that over exertion, to include lifting objects more than 23 kg, was the leading cause of non-fatal injuries.[186] A second study identified occupations requiring lifting of 20 kg or more at least twice daily to be associated with low back injury.[51] Previous male dominated research on deployed soldiers indicates that risk increased at 36kg, over 10 kg more of tolerance.[160] The male soldiers appear to be able to lift heavier weights than both the female soldiers and civilians. The industry studies almost entirely consisted of men as well, but the civilian participants were older than the soldiers. The male soldiers are younger and therefore likely more physically fit than the civilian men. The female soldiers can lift the same weight as the civilian men before risk of MSI increased. It is likely that more weight training for these women could increase the amount of weight they could safely lift. It has been shown that proper training can increase the load that women can lift as well as the frequency of lifts they can accomplish.[48,185] Training designed to increase lifting strength might reduce MSI in female soldiers.

As well as weight and lifting frequency, the average distance the object was carried also increased the relative risk of MSI. Carrying the object more then 7.6 m increased the risk of MSI by 201%. This average distance was not a factor in multivariate analysis. This factor has not been previously studied in a military sample but the Manual Handling Operations Regulations from the Health and Safety Executive in the United Kingdom identified carrying an object more than 10 m as a task that increased the mechanical stress on the back and found it could result in injury.[50] It is possible that by making more carts or dollys available to soldiers this risk can be decreased. The soldier could simply load the object on a cart or dolly instead of carrying it.

3.5.3 Sit Ups

The current study found that performing more sit ups during the APFT prior to deployment was a protective factor for injury. Sit ups as a risk factor for injury in the military have only been studied in training environments. Risk factors for injury calculated with both sexes combined included greater age, female sex, slower run times, fewer push-ups and sit ups, smoking, history of injury, and high running mileage.[22,63] However, when analyses were performed on men and women separately, sit ups were not a risk factor for women in basic training, only men.[16,63] The present study is the first study to look at sit ups as a risk factor for injury in Army women outside of the training environment. The women in the current study completed more sit ups (mean=70) than those in training (mean=34).[63] In the basic training study only 25% of the women completed over 45 sit ups.[63] In the current study, 98% of the women completed over 45 sit ups. It is possible that doing more sit ups is protective against injury as found in the current study, but that the protection starts at more repetitions than performed by the women in basic training. An ROC curve shows that 77 was the best cut off to use to correctly identify those that suffered MSI versus those that did not. It is likely that too few women in basic training even reached this cut off for sit ups to be found to be protective during training.

Two minutes of sit ups performed in the APFT have been identified as one measure of core strength.[127] Increasing core strength in female soldiers could reduce injuries. A core stabilization program performed by firefighters successfully reduced the number of injures they suffered.[187] Time loss injuries decreased by 66% and injury incidence decreased by 44%.[187] Core stabilization programs in athletes decreased back and knee injuries.[188,189] Increasing core strength and stability improves the trunk's muscles' ability to hold the trunk still while motion in other joints is occurring.[190] It also serves to transfer power and torque during movements.[190] Additionally, the spine is a series of joints that will become unstable under compression (like that caused by body armor or a backpack) and buckle unless surrounding soft tissue can reinforce it. Musculature has been shown to be the most important structure for overcoming this force and stronger musculature is needed to withstand heavier loads.[191,192] More strength could translate into tolerance for wearing heavier equipment. Increasing evidenced based core stabilization training conducted during Army physical training could decrease injuries in female soldiers.

3.5.4 Body Armor

Univariate analysis indicated wearing body armor, regardless of type, did significantly increase the risk of injury. The type of body armor did not affect injury although risk increased with a plate carrier (10 kg) compared to the Improved Outer Tactical Vest (IOTV)(14 kg), but not significantly so. Relative risk increased 62% with 1-4 hours of body armor wear while wearing body armor for four or more hours increased the risk by 84%. This is somewhat consistent with previous research by Konizter et al.,[2] finding that soldiers wearing body armor for four hours or more were at greater risk of musculoskeletal pain. In another deployment study, it was found that wearing body armor more than six hours increased the risk of low back pain.[193] In both studies the sample was at least 80% male. Both studies focused on spine pain and did not look for risk factors for all MSI. It is possible that the other body regions included in the current study were more susceptible to body armor wear and became injured in less than four hours. It is also possible that women have shorter tolerances for body armor than men and become injured sooner.

The plate carrier is 10 to 15 lbs. lighter than the IOTV but there was no difference in injury rates between the two types of body. Additionally, a logistic regression was used to test if the type of body armor was a moderator for time spent wearing body armor. For example, could soldiers wear the lighter plate carrier longer than the IOTV before becoming injured? Body armor type was not a moderator for time spent wearing body armor (data analysis not shown). It is unlikely that body armor will get lighter than the plate carriers in the foreseeable future. Therefore, it would be better to investigate if training could increase women's tolerance for body armor or if a different style of body armor could decrease injuries.

3.5.5 Balance

The Y Balance Test is used to measure dynamic balance. In the current study scoring below the 35th percentile resulted in a 71% increased risk of MSI in univariate analysis. Those with the worst balance were at greater risk of injury. Impaired standing balance has been identified as a primary risk factor in the occurrence of falls and associated injuries in older adults.[194] Poor balance has also been identified as a risk factor for injury in athletes in multiple studies.[73-79] The Y Balance or Star Excursion tests have been used in several of these studies as the measure of balance.[75-79] One study found that girls with asymmetrical movement (balance different on the left versus right leg) on the Y Balance Test were 2.7 times more likely to suffer a lower extremity injury.[75] The current study did not find that asymmetry increased the risk of injury; but it is possible that asymmetry is a predictor for lower extremity injuries only and not all MSI. Poor overall balance did increase the relative risk of MSI. The previous study used high school girls' basketball players. The two populations are different and that could explain the discrepancy in results. The high school girls were younger and playing a fast-paced sport. This might not be comparable to the women who are not playing sports but walking and running on uneven terrain. It is likely that on this uneven terrain, overall balance is more important than left/right discrepancies, whereas in fast-paced cutting sports the left/right asymmetry becomes more important. Additionally, most soldiers did not have asymmetries. It is possible that there was not enough variability in balance asymmetry in the sample to find a difference between those with and without injury. Training can be designed to improve muscle recruitment, increase reaction time, increase neuromuscular control, and increase balance and proprioception.[195] Proprioceptive training can improve joint position sense, postural sway, and muscle reaction times.[196] Studies have demonstrated that these programs can improve balance and reduce the risk of lower extremity injury.[80-82] Injuries in soldiers may decrease with such training as it has with athletes.

3.5.6 Non-predictive Variables

3.5.6.1 Prior Deployment

Neither a history of deployment nor the number of prior deployments, were associated with MSI. One previous deployment study did find that a history of prior deployment increased the risk of injury.[12] Other deployment studies made no mention of history of deployment as a studied variable. The previous study was over 80% male and included airmen, sailors, and marines. It is possible that history of deployment is a risk factor for injuries in men but not in women, or in other branches of the military but not the Army. There was no association between the number of previous deployments and MSI in the current study, but there may not have been a large enough range. There may be a specific number of deployments at which point the risk of MSI increases. In the current study the maximum number of deployments was only three. It is possible that the soldiers in the Skeehan[12] study had more than three deployments (number of previous deployments was not collected in that study). Therefore, this variable should be further studied in the future.

3.5.6.2 Weight Bearing Activities

The present study investigated walking and standing as possible risk factors, however, results indicated neither were. Soldiers in the current study had a median time of two hours a day of both standing and walking and walked a median of 3.2 km. Some studies found that walking or standing were risk factors for injuries while others have not. Only one study in deployed soldiers investigated the effect of standing on MSI in general and reported that standing more than 12 hours a day increased the risk of injury.[160] Standing has also been shown to be a risk factor for low back pain in some studies. In a study of 1,412 workers, those who stood for two hours or more had an increased risk of low back pain.[54] In a study by Knox et al.,[54] walking more than two hours was noted to be a risk factor for low back pain in workers. These finding are contradictory to findings in several other studies suggesting that walking and standing are not risk factors for injury.[59-62] For instance, a study of 1,186 workers from various occupations did not find walking or standing to be a risk factor for low back pain.[59] A second study of 144 nurses also found that neither standing nor walking were risk factors for low back pain.[62] It is possible that there is a floor effect. In the current study only three women stood for 12 hours per day, and two of them became injured. Relative risks are not calculated for levels with only three people. Additionally, the current study investigated all MSIs and not just low back pain. Future studies could verify if 12 hours is a good cut-off by looking at a sample of female soldiers that stood for longer periods of time to give the data a larger range with either normal or negatively skewed data. Overall, standing and walking are not likely to be risk factors for injury in populations similar to the sample in the current study.

3.5.6.3 Endurance

Neither overall fitness, nor push-ups, nor 2-mile run time, were found to be risk factors for MSI in the current study. This was somewhat surprising as multiple studies have shown that less aerobic endurance, measured using a distance run, to be a risk factor for injury in both men and women in basic training.[63,66,67,69] Additionally, lower extremity endurance measured as a loaded step test has also been shown to be a risk factor for injuries in professional male soldiers.[70] The majority of studies identifying lower endurance as a risk factor were done on recruits and the step test was used with European military men. Recruits generally are not as fit as professional soldiers and men are often different than women. The average APFT for females at the end of basic training was 205 out of 300 (which is a passing score but is considered a poor score) and the average score in the current study was 263 (which is considered a moderate score).[197] Basic training studies have found that slower runners were at increased risk of MSI. Women who ran two miles in more than 19 minutes and 48 seconds, were at an increased risk.[197] In the current study less than 2% of the women ran slower than 19 minutes and 48 seconds, whereas in the basic training study, 75% of women ran slower than 19 minutes and 48 seconds. Push-ups are often a risk factor in basic training as well.[16,197] The average in basic training was 25 push-ups, while in the current study, the average was 42.[197] Performing less than 6 push-ups was a risk factor for MSI.[197] The minimum amount of push-ups done in the current study was 17. Push-ups and run time may be a risk factor for MSI in deployed women as well as basic training, but almost no deployed women scored in the range that increased risk of injury. The range of values was too limited to fins a relationship with MSI. The fitness levels of the deployed women were all above the thresholds for injury found in women in basic training. No improvement in overall fitness, push-ups, or running seems to be needed in deployed women in regards to MSI risk.

Soldiers have to sprint while on the battle field but rarely in a straight line. Soldiers also rarely walk in a straight line as they go about their occupational tasks. The Illinois Agility Test is a method of agility testing using sprinting and changes in direction.[86-89] In the current study Illinois Agility times did not predict MSI. It is likely that this form of testing agility is not useful in predicating MSI in this population. Compared to high school female athletes, the women in this study all had average or worse agility scores.[87] The scores of the women in the current study were closer to a second study investigating a sample of participants 18 years-old and older.[88] The average score in this sample study was 16.8 and the average in the current study was 21.5. The previous study consisted of only 32% women so the men in the study are likely making the mean time speed up.[88] Balance, a component of agility, was found to be a factor in predicting injury in the current study. It is possible that agility as measured by a sprint test is not important but the balance component is. As discussed earlier, the Y Balance Test offers a method of testing dynamic balance and may be more appropriate than a sprinting agility test.

3.5.6.4 Body Mass Index

Body mass index (BMI) was not a predictor of MSI in the current study. BMI was also not risk factor for MSI in several studies performed on recruits (basic training).[63,66,67] Conversely, studies done in non-training military environments have found higher BMI to be a risk factor for MSI in men.[27,68] Although these results concluded that BMI is not a risk factor for injury for deployed female soldiers, it is important to remember that the results of the present study may not be generalizable to civilians. Only 3% of the female soldiers were moderately obese and none of the participants were severely obese. In America, 32% of women age 20 to 39 were obese.[198] So while BMI was not a risk factor for MSI in female soldiers, it may be a risk factor for civilian American women.

3.5.6.5 Psychosocial Variables

Three psychosocial variables were investigated in this study: coping ability, sleep, and stress level. Coping ability did not predict MSI in the current study congruent with many previous studies. There are several studies showing no relationship between coping skills and injury in athletes.[199,200] Coping skills were shown not to predict injury in high school athletes.[199] It was thought that lack of sleep could be a risk factor for MSI. Those women who developed MSI during deployment had worse PSQI scores both before and during deployment compared to the non-injured women but not significantly worse than non-injured soldiers. Operational tempo, job stress, and other deployment related factors can lead to sleep disturbances such as circadian desynchronosis, sleep deprivation, sleep latency, and waking after sleep onset.[94,95] While sleep quality did not affect injury rates, sleep disruptions in normal sleep patterns are among the various sources of stress.[94,95] This increase in stress could possibly increase the risk of MSI. Additionally, sleep disturbances have been linked to psychiatric disorders and illness.[136] For these reasons steps should be taken to try and improve the sleep of female soldiers regardless of whether or not they are deployed.

The JCQ measures work stress. Neither portion of this scale was related to MSI at any time point in the current study, nor was it a moderator of the effect of the number of family members on MSI while controlling for brigade. It is possible that a measure of overall stress instead of job stress would be more relevant and might relate to injury instead of only work stress. A study on athletes also found that high life stress was a risk factor for injury.[201] A study of civilians found that more family members increased stress.[202] Higher stress can result in reduced blood flow to the extremities and muscles, increased blood pressure, increased cortisol levels, increased peripheral neurotransmitters, and increased muscle tension, all of which could increase the risk of injury.[109] Future studies should use a measure of overall stress that captures life stress as well as job stress.

Although not the main question of this study, we found that having more immediate family members increased the risk of MSI when brigade was controlled for during the analysis. This is not the first time that this has been found by a military study. Allison et al., found that the number of family members was a risk factor for overuse injuries in multivariate analysis for both men and women during basic training.[16] Being married (1 family member) was a risk factor for injury in Air Force women as well.[197] It is unknown why this variable is related to MSI, especially since the family members are not present during deployment or basic training. It is very likely that there are confounding variables. Having more family members may be increasing stress levels. It may be that overall life stress is a risk factor and not the number of family members or simply job stress.

This study has limitations. There are limited ranges and variability for some variables, particularly for the ones related to physical fitness. However, our sample is a good representation of female Soldiers who are deployed to combat zones. Therefore, it appears that fitness is truly not a concern as it relats to MSIs in deployed women. A second limitation was that most variables and the outcome variable were self-report. Electronic records do exist but often the medical note was written on paper and additionally many of the electronic notes do not upload to the main server. This results in very inaccurate electronic records. Therefore we chose to use the self-report data as has been done in previous studies on deployed populations.

Finally, for post deployment surveys, participants were instructed when answering the surveys to recall the time before they became injured. This creates a lag time between when they were injured and when they filled out the surveys. Participants must recall back several months creating possible recall bias. However, it would have been challenging to administer the surveys at the time of injury due to the logistics of locating personnel in Afghanistan.

3.6 CONCLUSION

The 160 Army females studied had an incidence of duty limiting MSI of 36%. Individual predictors for MSI were heavier worn loads and longer duration of wearing loads; lifting heavier objects, more repetitions of lifting objects, and carrying loads further; decreased dynamic balance; and fewer sit ups on the APFT. While controlling for brigade and number of family members the most parsimonious set of variables that best predicted MSI included: heavier loads worn, more repetitions of lifting objects and performing fewer sit ups on the APFT. These results suggest that injury prevention programs designed to improve load bearing ability, lifting endurance, and core strength should be considered to decrease MSI in deployed female soldiers.

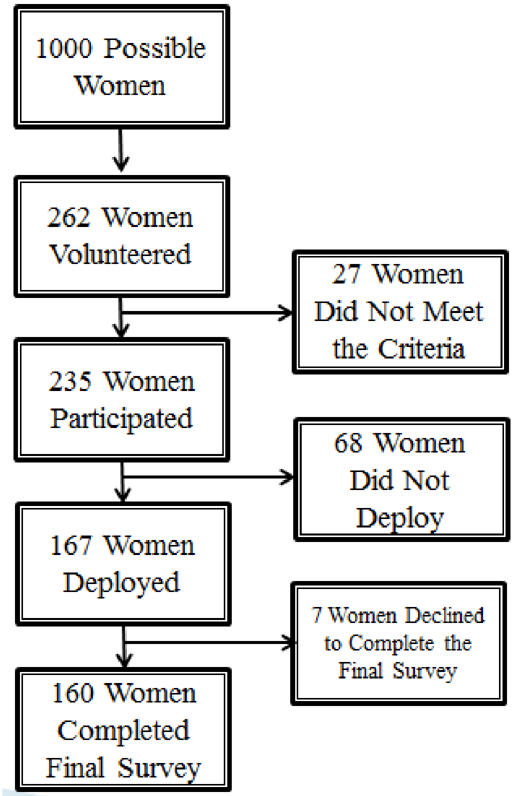

Figure 9. Participant Flow Chart

Table 6. Sample Characteristics

Variable	N	Percent
Marital Status		
Single	77	48
Married	65	41
Divorced	18	11
Family Size		
No spouse/children	103	64
1 family member	40	25
2 family members	7	4
3 family members	5	3
4 or more family members	5	3
Self-reported Health Status		
Excellent	44	27
Good	95	59
Fair	20	12
Poor	1	1

Table 6. (continued)

Smoker	47	29
Highest Education		
High School	34	21
Some College	80	50
Bachelor's Degree	40	25
Master's Degree	6	4
Brigade Combat Team		
Red brigade	74	46
White brigade	63	39
Blue brigade	23	15
Main Duty		
Working Indoors	108	68
Lifting and Carrying	19	12
Mechanic	3	2
Riding in Vehicles	7	4
Working off the FOB**	20	13
Guard Detail	3	2
Variable	**Median**	**Inter Quartile Range**
Age	25.0	6.0
Rank	E5*	2.0
Height (cm)	160.0	7.6
Weight (kg)	66.3	14.2
Body Mass Index (kg/m^2)	25.0	4.1
Army Physical Fitness Test	270.0	44.0
Number of Months Deployed	9.0	1.0
Days Worked per Week	7.00	2.0
Number of Previous Deployments	0	1.0

* E5=Sergeant

Table 7. Comparison of Differences in Variables

Variable	**Non-Injured**	**Injured**	**Unadjusted p-value***	**Adjusted p-value****
Demographic Variables				
Rank - Median (IQR)	5.00 (3.00)	4.00 (1.50)	0.29	0.82
Age - Median (IQR)	25.00 (6.50)	24.00 (6.00)	0.55	0.41
Number of Family Members - Median (IQR)	0.00 (1.00)	0.00 (1.00)	0.16	**0.04**
Number of Deployments - Median (IQR)	0 (1.00)	0 (1.00)	0.13	0.18

Table 7. (continued)

Brigade - N (%)			0.39	0.24
Red	49 (48)	25 (44)		
White	37 (36)	26 (46)		
Blue	17 (16)	6 (10%)		
Female Engagement Team - Mode (%)	No (76)	43 (75)	0.97	0.77
Marital Status - N (%)			0.23	0.66
Single	58 (56)	37 (65)		
Married	45 (44)	20 (35)		
Health Rating - N (%)			0.18	0.12
Fair	11 (11)	10 (18)		
Good	59 (57)	36 (63)		
Excellent	33 (32)	11 (19)		
Smoker - Mode (%)			0.79	0.94
Non-smoker	72 (70)	41 (72)		
Smoker	31 (30)	16 (28)		
Education Level - N (%)			0.98	0.98
High School	21 (20)	13 (23)		
Some College	53 (52)	27 (47)		
Bachelor's	25 (24)	15 (26)		
Master's	4 (4)	2 (4)		
History of Deployment - Mode (%)	No (59)	No (72)	0.23	0.15
Physical Variables				
Height (m) - Median (IQR)	1.64 (0.09)	1.63 (0.10)	0.63	0.22
Weight (kg) - Mean (SD)	66.92 (9.01)	68.48 (9.81)	0.28	0.31
Body Mass Index - Median (IQR)	24.44 (3.76)	25.27 (4.48)	0.12	0.13
APFT Score - Median (IQR)	272.00 (45.00)	270.00 (38.00)	0.29	0.39
Number of Push Ups - Median (IQR)	43.00 (18.00)	45.00 (15.00)	0.97	0.95
Number of Sit Ups - Mean (SD)	72.73 (11.40)	68.00 (11.87)	0.11	**0.04**
2-Mile Run Time (min) - Mean (SD)	16.26 (1.57)	16.75 (1.44)	0.22	0.18

Table 7. (continued)

Illinois Agility Time (sec) - Median (IQR)	20.81 (2.05)	22.00 (2.21)	0.16	0.82
Y Balance Composite L-R Limb Difference - Median (IQR)	2.71 (2.73)	2.28 (2.34)	0.14	0.79
Y Balance Best Composite Score - Median (IQR)	98.45 (10.45)	95.08 (11.61)	0.64	1.00
Loaded Step Test Time - Median (IQR)	106.50 (79.25)	128.50 (118.00)	0.92	0.72
APFT Categories - N (%)			0.40	0.37
Did not take it	4 (4)	5 (9)		
Failed	2 (2)	2 (4)		
180-249	23 (22)	11 (19)		
250-269	22 (21)	12 (21)		
270-289	26 (25)	19 (33)		
≥ 290	26 (25)	8 (14)		
Illinois Agility Test Categories (sec) - N (%)			0.18	0.23
Did not take it	12 (11)	7 (12)		
>23	16 (16)	8 (14)		
21.8-23	16 (16)	17 (30)		
18-21.7	59 (57)	25 (44)		
Occupational Variables				
Months Spent Deployed - Median (IQR)	9.00 (1.00)	9.00 (2.00)	0.95	0.82
Days Worked per Week- Median (IQR)	7.00 (2.00)	7.00 (2.00)	0.47	0.82
Hours/Day Wearing Body Armor- Median (IQR)	0.00 (2.00)	1.00 (3.00)	**0.04**	0.26
Hours/Day Wearing Back Pack- Median (IQR)	0.00 (1.00)	1.00 (1.50)	**0.003**	0.16
Hours/Day Spent Sitting- Median (IQR)	6.00 (4.50)	6.00 (5.25)	0.76	0.64
Hours/Day Spent Standing- Median (IQR)	2.00 (3.00)	2.00 (2.00)	1.00	0.68
Hours/Day Spent Walking- Median (IQR)	2.00 (3.00)	2.00 (3.00)	0.95	0.85
Hours/Day on Feet- Median (IQR)	5.00 (5.75)	4.00 (4.00)	0.92	0.91

Table 7. (continued)

Distance Walked/Day (km)- Median (IQR)	3.22 (4.83)	3.22 (4.83)	0.44	0.55
Average Load as % of Body Weight- Median (IQR)	5.41 (19.69)	14.51 (24.64)	**0.001**	**<0.001**
Time Spent Wearing the Average Load- Median (IQR)	0.50 (3.00)	2.00 (6.13)	**0.001**	**0.01**
Heaviest Load as % Body Weight- Median (IQR)	25.48 (22.30)	34.89 (21.53)	**0.002**	**0.002**
Time Spent Wearing Heaviest Load- Median (IQR)	2.00 (3.00)	3.00 (4.25)	**0.03**	**0.01**
Days/Week of Heavy Lifting- Median (IQR)	1.00 (4.00)	2.00 (5.00)	0.13	0.09
Average Weight Lifted (kg)- Median (IQR)	6.80 (14.97)	13.61 (21.55)	**0.008**	**0.001**
Average Number of Times Object Lifted- Median (IQR)	1.00 (3.00)	2.00 (3.00)	**0.04**	**0.004**
Average Distance Object Carried (m)- Median (IQR)	0.30 (6.10)	4.57 (15.24)	**0.005**	**0.04**
Work Environment - N (%)			0.29	0.36
Working Indoors	72 (70)	36 (63)		
Lifting and Carrying	15 (15)	7 (12)		
Working Off the Base	14 (15)	14 (25)		
Type of Body Armor - N (%)			0.33	0.23
Improved Outer Tactical Vest	70 (68)	32 (56)		
Plate Carrier	33 (32)	25 (44)		
Height Object Lifted From - N (%)			0.89	0.87
The Floor	42 (71)	31 (72)		
Knee Height	6 (10)	6 (14)		
Waist Height	9 (15)	5 (12)		
Overhead	2 (3)	1 (2)		
Height Object Lifted To			0.26	0.10
The Floor	5 (9)	1 (2)		
Waist Height	31 (52)	20 (47)		
Chest Height	18 (30)	20 (47)		
Overhead	5 (9)	2 (3)		

Table 7. (continued)

Psychosocial Variables				
Pre-Deployment Brief Cope Score- Median (IQR)	61.00 (23.50)	58.00 (20.00)	0.08	0.19
Pre-Deployment JCQ Psychological Score- Median (IQR)	13.00 (2.00)	13.00 (1.00)	0.93	0.60
Pre-Deployment JCQ Control Score- Median (IQR)	26.00 (5.00)	25.00 (6.00)	0.38	0.58
Pre-Deployment PSQI Score- Median (IQR)	8.00 (7.00)	10.00 (6.00)	0.13	0.53
Post-Deployment Brief Cope Score- Median (IQR)	55.00 (28.50)	54.00 (23.00)	0.81	0.80
Post-Deployment JCQ Psychological Score- Median (IQR)	14.00 (2.00)	14.00 (1.00)	0.47	0.55
Post-Deployment JCQ Control Score - Mean (SD)	25.38 (4.25)	26.09 (7.00)	0.58	0.41
Post-Deployment PSQI Score- Median (IQR)	7.00 (5.00)	9.00 (7.00)	0.06	0.14
Pre-Deployment JCQ (high strain/low strain) - Mode (%)	Low (89)	Low (84)	0.35	0.57
Post Deployment JCQ (high strain/low strain) - Mode (%)	Low (89)	Low (88)	0.61	0.40

* p-value for non-adjusted comparison between injured and non-injured groups (T-test, Mann Whitney U Test, or χ^2).

** p-value for logistic regression models adjusted for brigade and family members

APFT – Army Physical Fitness Test

JCQ – Job Content Questionnaire 14

PSQI – Pittsburgh Sleep Quality Index

Table 8. Relative Risk of Injury

Variable	Level	Injured N (%)	Non-Injured N (%)	Total	RR	95% CI
Demographic Variables						
Brigade (Group)	Red Brigade	25 (34)	49 (66)	74	1.30	0.61-2.76
	White Brigade	26 (41)	37 (59)	63	1.58	0.75-3.34
	Blue Brigade	6 (26)	17 (74)	23	1	
Female Engagement Team	Yes	14 (36)	25 (64)	39	1.01	0.62-1.64
	No	43 (36)	78 (64)	121	1	
Rank	E1-4	30 (40)	45 (60)	75	1.67	0.79-3.53
	E5-7	21 (35)	39 (65)	60	1.46	0.67-3.18
	W1-O10	6 (24)	19 (76)	25	1	
Age	≤25	36 (40)	55 (60)	91	1.3	0.84-2.01
	>25	21 (30)	48 (70)	69	1	
Marital Status	Single	37 (40)	58 (60)	95	1.27	0.81-1.97
	Married	20 (31)	45 (69)	65	1	
Health Rating	Fair/Poor	10 (48)	11 (52)	21	1.91	0.97-3.76
	Good	36 (38)	59 (62)	95	1.52	0.86-2.69
	Excellent	11 (25)	33 (75)	44	1	
Smoker	No	41 (36)	72 (64)	113	1.07	0.67-1.70
	Yes	16 (34)	31 (66)	47	1	
Number of Family Members	0	40 (39)	63 (41)	103	1.30	0.82-2.08
	>0	17 (30)	40 (70)	57	1	
Education Level	High School/GED	13 (38)	21 (62)	34	1.10	0.67-1.79
	Some College or More	44 (35)	82 (65)	126	1	
History of Deployment	Yes	16 (28)	41 (72)	57	1	
	No	41 (40)	61 (60)	102	1.43	0.89-2.31
Previous Injury	Yes	14 (35)	26 (65)	40	1	
	No	43 (36)	77 (64)	120	1.02	0.63-1.66
Physical Variables						
Height	≤1.63 m	26 (36)	46 (64)	72	1.03	0.68-1.56
	>1.63 m	31 (35)	57 (65)	88	1	
Weight	≤71.56 kg	35 (34)	69 (66)	104	1	
	>71.56 kg	22 (39)	34 (61)	56	1.05	0.71-1.55

Table 8. (continued)

Body Mass Index	<25 kg/m2	26 (32)	56 (68)	82	1	
	≥25 kg/m2	31 (40)	47 (60)	78	1.25	0.82-1.91
APFT	<270	25 (35)	47 (65)	72	1.02	0.65-1.58
	≥270	27 (34)	52 (66)	79	1	
Sit Ups	<63	16 (41)	23 (59)	39	1.23	0.77-1.96
	≥63	35 (33)	70 (67)	105	1	
Push Ups	<42	19 (35)	35 (65)	54	1.15	0.72-1.84
	≥42	30 (31)	68 (69)	98	1	
Run Time	≤15.57	11 (23)	37 (77)	48	1	
	>15.57	35 (40)	53 (60)	88	1.74	0.97-3.10
Y Balance Composite L- R Limb Difference	≤4 cm	42 (39)	66 (41)	108	1.38	0.79-2.40
	>4 cm	11 (28)	28 (72)	39	1	
Y Balance Composite Best Score	≤95.23	21 (51)	20 (49)	41	**1.71**	**1.13-2.60**
	>95.23	32 (30)	75 (70)	107	1	
Step Test	<132	25 (28)	65 (72)	90	1	
	≥132	21 (44)	27 (56)	48	1.58	0.99-2.501
Illinois Agility Test	<21.8 sec	25 (30)	59 (70)	84	1	
	≥21.8	25 (44)	32 (56)	57	1.47	0.95-2.29
Occupational Variables						
Months Deployed	≤ 9	20 (37)	34 (63)	54	1.06	0.69-1.64
	>9	37 (35)	69 (65)	106	1	
Days per Week Worked	1-6	20 (31)	44 (69)	64	1	
	7	37 (39)	59 (61)	96	1.23	0.79-1.92
Work Environment	Indoors	36 (33)	72 (67)	108	1	
	Lifting and Carrying	7 (32)	15 (68)	22	0.96	0.49-1.86
	Off the FOB	11 (41)	16 (59)	27	1.22	0.72-2.07
Type of Body Armor	IOTV	32 (31)	70 (69)	102	1	
	Plate Carrier	25 (43)	33 (37)	58	1.37	0.91-2.08

Table 8. (continued)

Hours/Day Spent Wearing Body Armor	0	19 (26)	54 (74)		1	
	1-4	27 (42)	37 (58)		**1.62**	**1.002-2.62**
	>4	11 (48)	12 (52)		**1.84**	**1.03-3.27**
Hours/Day Spent Wearing a Back Pack	0	27 (27)	73 (73)	100	1	
	>0	30 (50)	30 (50)	60	**1.85**	**1.23-2.80**
Hours/Day Spent Sitting	0-4	14 (33)	28 (67)	42	1	
	5-8	28 (36)	49 (64)	77	1.09	0.65-1.84
	>8	15 (24)	26 (74)	41	1.10	0.61-1.98
Hours/Day Spent Standing	0-4	50 (38)	81 (62)	131	1.58	0.80-3.12
	>4	7 (24)	22 (76)	29	1	
Hours/Day Spent Walking	<3	35 (38)	57 (62)	92	1.18	0.76-1.81
	≥3	22 (32)	46 (68)	68	1	
Hours on Feet	<6	33 (36)	59 (64)	92	1.02	0.67-1.55
	≥6	24 (35)	44 (65)	68	1	
Distance Walked per Day	0-2 miles (0-3.22km)	31 (34)	59 (66)	90	1	
	>2 miles (>3.22km)	26 (37)	44 (63)	70	1.08	0.71-1.64
Average Load as % of Body Weight	≤10%	23 (25)	69 (75)	92	1	
	>10%	34 (50)	34 (50)	68	**2**	**1.31-3.06**
Hours/Day Spent Wearing Average Load	0	10 (17)	48 (83)	58	1	
	1-4 hours	29 (42)	40 (58)	69	**2.44**	**1.30-4.57**
	>4	18 (55)	15 (45)	33	**3.16**	**1.66-6.02**
Heaviest Load as % of Body Weight	≤15%	2 (7)	26 (93)	28	1	
	> 15%	55 (42)	77 (58)	132	**5.83**	**1.51-22.50**

Table 8. (continued)

Hours/Day Spent Wearing the Heaviest Load	0	3 (21)	11 (79)	14	1	
	1-4 hours	37 (34)	73 (66)	110	1.42	0.50-4.04
	>4	17 (47)	19 (53)	36	2.20	0.76-6.37
Days per Week Spent Lifting	0	16 (27)	43 (73)	59	1	
	1-3 times	21 (40)	31 (60)	52	1.49	0.87-2.54
	4-7 times	20 (41)	29 (59)	49	1.51	0.88-2.58
Average Weight of Object Lifted	0	14 (25)	43 (75)	57	1	
	1-25 lbs (0-11.34kg)	13 (38)	21 (62)	34	1.56	0.83-2.91
	26-50 lbs (11.79-22.68 kg)	17 (40)	25 (60)	42	1.65	0.92-2.96
	>50 lbs (22.68 kg)	13 (48)	14 (32)	27	**1.96**	**1.08-3.57**
Average Number of Times Object Lifted	0	14 (25)	43 (75)	57	1	
	1-2 times	25 (38)	34 (62)	59	**1.73**	**1.002-2.97**
	>2 times	18 (41)	26 (39)	44	1.67	0.94-2.97
Distance Object Carried	0	16 (24)	50 (76)	66	1	
	1-25 feet (1-7.62 m)	21 (40)	32 (60)	53	1.63	0.95-2.81
	>25 feet (>7.62 m)	20 (49)	21 (51)	41	**2.01**	**1.19-3.42**
Height Object Lifted From	The Floor	31 (42)	42 (58)	73	1.42	0.94-2.16
	Above the Floor	26 (30)	61 (70)	87	1	
The Height Object Lifted To	Waist Height or Lower	21 (37)	36 (63)	57	**4.61**	**1.17-18.16**
	Chest Height or Higher	2 (8)	23 (92)	25	1	

Table 8. (continued)

Psychosocial Variables						
Pre-Deployment Brief Cope Score	35th percentile (50)	24 (42)	33 (58)	57	1.31	0.87-1.99
	>50	33 (32)	70 (68)	103	1	
Pre-Deployment PSQI Score	≤5	10 (23)	34 (77)	44	1	
	>5	47 (41)	69 (59)	116	1.78	0.99-3.21
Pre-Deployment JCQ Psychological Score	35th percentile (13)	37 (38)	61 (62)	98	1.17	0.75-1.8
	>13	20 (32)	42 (48)	62	1	
Pre-Deployment JCQ Control Score	35th percentile (24)	24 (40)	36 (60)	60	1.21	0.80-1.84
	>24	33 (41)	67 (59)	80	1	
Pre-Deployment JCQ	Low Job Strain	48 (34)	92 (66)	140	1	
	High Job Strain	9 (45)	11 (55)	20	1.31	0.77-2.24
Post-Deployment Brief Cope	35th percentile (46)	19 (33)	38 (67)	57	1	
	>46	38 (37)	65 (63)	103	1.11	0.71-1.73
Post-Deployment PSQI	≤5	13 (30)	31 (70)	44	1	
	>5	44 (38)	72 (62)	116	1.28	0.77-2.14
Post-Deployment JCQ Psychological Score	35th percentile (13)	29 (36)	51 (64)	80	1.04	0.68-1.57
	>13	28 (35)	52 (65)	80	1	
Post-Deployment JCQ Control Score	35th percentile (24)	22 (37)	38 (63)	60	1.05	0.68-1.61
	>24	35 (44)	65 (56)	80	1	

Table 8. (continued)

Post-Deployment JCQ	Low Job Strain	51 (36)	92 (64)	143	1.01	0.51-2.00
	High Job Strain	6 (35)	11 (65)	17	1	

RR – Relative Risk

CI – Confidence Interval

E – Enlisted Ranks

W – Warrant Officer Ranks

O – Officer Ranks

APFT – Army Physical Fitness Test

JCQ – Job Content Questionnaire 14

PSQI – Pittsburgh Sleep Quality Index

Table 9. Best 5 Models for Physical and Occupational Variables

Number of Variables	χ^2	**Variables in Model**	**AIC**	**ROC AUC**
7	39.10	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, # of times object lifted, Distance object carried, Sit-ups	163.70	0.80
8	40.39	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, time carrying the heaviest load, # of times object lifted, Distance object carried, Sit ups	162.19	0.82
7	36.26	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, # of times object lifted, Sit ups	163.99	0.80
8	40.19	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, Average weight of objects lifted, # of times object lifted, Sit ups	163.15	0.81

Table 9. (continued)

9	41.49	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, time wearing the heaviest load, Average weight of objects lifted, # of times object lifted, Distance object carried, Sit ups	**161.70**	**0.82**

AIC – Akaike Information Criterion

ROC – Receiver Operating Characteristics

AUC – Area Under the Curve

Table 10. Best Predictive Logistic Regression Model for Physical and Occupational Variables

Variables	**β**	**SE**	**Wald**	**df**	**Sig.**	**OR**	**95% CI for OR**	
							Lower	Upper
Brigade			3.22	2	0.20			
Brigade (Red vs. White)	-0.03	0.45	0.004	1	0.95	0.97	0.40	2.35
Brigade (Red vs. Blue)	-1.22	0.70	3.02	1	0.08	0.30	0.07	1.18
Number of Family Members	-0.44	0.25	3.05	1	0.08	0.64	0.39	1.06
Average Load Worn as % Body Weight	0.04	0.02	7.06		0.008	1.04	1.01	1.07
Heaviest Load Worn as % Body Weight	0.03	0.01	6.04	1	0.01	1.03	1.01	1.05
# of Times Object Lifted	0.07	0.03	4.65	1	0.03	1.07	1.01	1.14
Sit Ups	-0.04	0.02	5.49		0.02	0.96	0.93	0.99
Constant	0.95	1.28	0.55	1	0.46	2.58		

SE – Standard Error

df – Degrees of Freedom

Sig. – Significant

OR – Odds RatioCI – Confidence Interval

Table 11. All Subset Models for Psychological Variables

Number of Variables	χ^2	Variables in Model	AIC	ROC AUC
4	10.471	Brigade, Family Members, PSQI score, Pre-Deployment Brief Cope	**208.98**	**0.67**
3	8.335	Brigade, Family Members, PSQI score	209.39	0.63
2	6.301	Brigade, Family Members	209.54	0.59
3	1.8971	Brigade, Family Members, Pre-Deployment Brief Cope	209.82	0.64

PSQI – Pittsburgh Sleep Quality Index

AIC – Akaike Information Criterion

ROC – Receiver Operating Characteristic

AUC - Area Under the Curve

Table 12. Best Logistic Regression Model for Psychological Variables

Variable	β	S.E.	Wald	df	Sig.	OR	95% CI OR	
							Lower	Upper
Brigade			2.84	2	0.24			
Brigade(Red vs. White)	0.42	0.37	1.35	1	0.25	1.53	0.75	3.12
Brigade(Red vs. Blue)	-0.43	0.54	0.64	1	0.42	0.65	0.23	1.87
Family Members	-0.44	0.22	4.05		0.04	0.65	0.42	0.99
Constant	-0.49	0.26	3.54	1	0.06	0.61		

SE – Standard Error

df – Degrees of Freedom

Sig. – Significant

OR – Odds Ratio

CI – Confidence Interval

Table 13. All Subset Models with Physical, Occupational, and Psychosocial Variables

Number of Variables	χ^2	Variables in Model	AIC	ROC AUC
8	42.30	Brigade, Family Members, Average load as % body weight , Heaviest load as % body weight, # of times object lifted, Distance object carried, Sit ups, Pre-Deployment Brief Cope	163.07	0.81
9	44.19	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, # of times object lifted, Distance object carried, Sit ups, Pre-Deployment Brief Cope	161.96	0.82
9	44.17	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, Time the heaviest load was worn for, # of times object lifted, Distance object carried, Sit Ups, Pre-Deployment Brief Cope	161.40	0.82
10	45.87	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, Time the heaviest load was worn for, Distance object carried, Sit ups, PSQI, Pre-Deployment Brief Cope	**160.68**	**0.83**
9	43.57	Brigade, Family Members, Average load as % body weight, Heaviest load as % body weight, Average weight of object lifted, # of times object lifted, Distance object carried, Sit ups, Pre-Deployment Brief Cope	162.02	0.82

AIC – Akaike Information Criterion

ROC – Receiver Operating Characteristic

AUC - Area Under the Curve

Table 14. Best Logistic Regression Model for All Variables

Variable	β	SE	Wald	df	Sig.	OR	95% CI OR	
							Lower	Upper
Brigade			3.22	2	3.22			
Brigade(Red vs. White)	-0.03	0.45	0.004	1	0.95	0.97	0.40	2.35
Brigade(Red vs. Blue)	-1.22	0.70	3.02	1	0.08	0.30	0.07	1.17
Family Members	-0.44	0.25	3.05	1	0.08	0.64	0.39	1.06
Average load as % body weight	0.04	0.02	7.06	1	0.01	1.04	1.01	1.07

Table 14. (continued)

Heaviest load as % body weight	0.03	0.01	6.04	1	0.01	1.03	1.01	1.05
# of Times Object Lifted	0.07	0.03	4.65	1	0.03	1.07	1.01	1.14
Sit Ups	-0.04	0.02	5.49	1	0.02	0.96	0.93	0.99
Constant	0.95			1				

SE – Standard Error

df – Degrees of Freedom

Sig. – Significant

OR – Odds Ratio

CI – Confidence Interval

4.0 SIGNIFICANCE AND DIRECTION OF FUTURE RESEARCH

Women make up 10-15% of U.S. Army and this has resulted in scarcity of research on female soldiers.[11,14,21,22] In many cases research focuses on male soldiers or a combined sample that is still 80% male as these participants are easier to find. As a result, a great deal of future research is needed on musculoskeletal injuries in female soldiers especially with combat military occupational tasks becoming open to women in the near future.

The aims of the current study were to identify the incidence of MSI, the body region most commonly injured, the activity most often associated with injury and the model that best predicted MSI. This study found that 35.6% of the deployed women were injured to such a degree that it caused limitations to either their physical training or occupational tasks. Most of these injuries (23%) were to the knee. Soldiers stated that physical training had led to most injuries, (31%). The variables that best predicted MSI were the higher average load and heaviest load, lifting objects for more repetitions, and performing fewer sit ups on the APFT while controlling for brigade and number of family members.

In the current study the knee was the most commonly injured body region. The knee has been shown to be the either the most frequently injured body region or second to the ankle in women in previous studies as well.[27,28,63,125,161] Studies in athletes have shown that female athletes are at increased risk of knee injury compared to male athletes.[162,163] Differences in joint laxity, pelvic geometry, lower limb alignment, and intercondylar notch have all been suggested as the cause of the increased risk.[163] Additionally, differences in jumping and landing patterns have also been identified as possible mechanisms of injury in athletes.[162,163] There is not a lot of jumping required by Army occupations so it is likely that something else is responsible for these knee injuries in soldiers. It may be that walking and running over uneven terrain is responsible for the large number of knee injuries. Tripping or falling was the second most common self-reported cause of injury, 17%. Most of the walkways on the bases in Afghanistan are either dirt or covered with rocks. In a study on a 12 month deployment to Afghanistan, tripping or falling accounted for just under 8% of injuries.[167] Traversing uneven terrain was cited as the cause of 7% of injuries in physical therapy patients in Afghanistan.[20] Loss of balance on this uneven terrain could result in forces being transmitted to the knee joints resulting in sprains. Possibly increasing lower extremity proprioceptive/neuromuscular training could reduce the number of injuries due to loss of balance. Balance training has resulted in a significant decrease in knee injuries and might help reduce knee injuries in military women.[163,203-205]

With the inclusion of women in the infantry, it is important for more research on the effects of wearing heavy equipment on female soldiers and methods to mitigate any risk from these loads. According to Department of the Army Pamphlet 611-21, soldiers in the infantry must be able to wear a minimum of 65 lbs. and must be able to carry a 160 lbs. person on his or her back.[206] He or she also must be able to lift 55 lbs. frequently and occasionally carry 153 lbs. for10 meters.[206] The current study points out the importance of further research in this area on female soldiers. In this study women self-reported that 18% of injuries were from either wearing body armor or lifting and carrying objects. Further analysis discovered that wearing body armor even one hour a day increased the risk of MSI. The plate carrier is 10 to 15 lbs. lighter than the

Improved Outer Tactical Vest but there was no difference in injury rates between the two types of body armor. It is unlikely that body armor will get lighter than the plate carriers in the foreseeable future. It would be better to investigate if training could increase women's tolerance for wearing equipment. The women in the current study were able to wear an average load up to 29 lbs. before there was a significant risk of injury. This is approximately the weight of their body armor but is well shy of the minimum 65 lbs. required by the infantry. Sixty-five pounds would represent body armor plus an additional back pack. Adding this back pack seems to increase the risk and this was supported by the current study. We found that wearing a back pack for any amount of time increased the risk of injury. In order to join the infantry, women must be able to wear a back pack in addition to body armor. Women in the current study also had an increased risk of injury when their heaviest load was greater than 48 lbs. This is also much less than the 160 lbs. required by the infantry. One study on civilian women found that strength training could significantly improve their speed with completing two miles while wearing a load.[48] Another study found that periodized weight training and plyometric exercises increased the speed at which women could run while wearing a 75 lbs. back pack.[207] These studies show that women can increase the level of physical demands they are able to accomplish with training. It may be that this training may also raise the weight at which injury risk increases. For example, instead of risk increasing with weights above 29 lbs. as found in the current study, training may result in risk increasing at 50 or 60 lbs. No one has investigated the affect increased strength might have on injury risk in female soldiers.

In the current study there was a trend of increasing risk as the weight of objects lifted increased with a significant rise in risk with weights over 50lbs. The odds of becoming injured also increased with the frequency of lifting objects. Female soldiers must be able to lift weights above 50 lbs. to perform their occupational tasks. Training could possibly be used to increase the weights women are able to tolerate and the number of times they can lift them. In one prior study, periodized strength training and plyometrics were used to increase the strength and endurance of the participants.[48] One repetition maximum box lift, repetitions of box lift, and loaded 2-mile run time all improved significantly in women who participated in the training. The U.S. Army is opening up combat occupations such as the infantry to women. According to regulations, infantry soldiers must be able to lift 55 lbs. frequently.[206] After training the women in that study significantly increased the number of times they could lift 50 lbs.[48] Those women are very close to being able to perform lifting tasks at the infantry level. After 24 weeks of training, the civilian women were able to lift over 30 lbs. more repetitively.[48] This improvement would put female soldiers in the current study well about the 55 lbs. threshold but it remains to be seen if this increase in strength comes with a decrease in injury risk. It has successfully been shown that women improve in physical military tasks with training and future research needs to be performed to assess if this would reduce the risk of injury. Future research needs to do two things. First, methods of increasing the weights that women can safely wear and carry and second, identifying which women will be able to successfully accomplish these tasks without increased risk of injury.

Instead of or in addition to training women to meet the level of physical tasks required by combat occupations, the military could also develop methods of testing to identify which females will be able to accomplish the physical tasks at the acceptable levels without an increased risk of injury. Currently no studies have investigated physical demands pre-test for identifying which soldiers can enter an occupation without a large injury risk. One study was able to identify predictors for civilian women’s ability to lift loads repetitiously and to run 2-miles with a 75 lbs.

load.[207] More explosive jump power, more push-ups, higher squat endurance, heavier 1 repetition box lift maximum weight, and faster two mile run time all predicted better repetitive box lifting ability.[207] Better squat endurance, faster 2-mile run time, and lower body mass all predicted better performance on a 2-mile run wearing 75 lbs.[207] These studies demonstrate tests that can predict successful performance. Future predictive equations need to be able to not only predict the ability to accomplish the required infantry tasks but also predict the risk of injury. In the current study neither 2-mile run time, loaded step test, nor BMI were predictive of injury. Sit ups were predictive of MSI injury in univariate models but not during multivariate models. Future studies should investigate if a combination of sit ups, run, jump power, maximum box lift, repetitive squat, and BMI could accurately predict both successful task completion and risk of injury. Future studies should also utilize larger samples. It is possible that some of these tests could predict injury but our study did not have enough power to detect it.

The current study found that female soldiers suffer a lot of knee injuries and appear to be injured by wearing and lifting heavy equipment. Incorporating injury prevention programs such as strength, balance, and proprioceptive training into military physical training could potentially serve to mitigate many of the injuries suffered by female soldiers. With the military opening up all occupations to women it has become very important for future research to develop injury prevention programs targeting these injuries. The ROC curve cut off 77 sit ups can be used as a starting point for identifying which female soldiers are more likely to succeed in the more physically demanding combat arms occupations. Sit ups can help identify female soldiers less likely to become injured but further research should be done to identify which tests predict the ability of female soldiers to perform combat arms occupational tasks.

APPENDIX A

AFGHANISTAN PHYSICAL ACTIVITY AND INJURY QUESTIONNAIRES

Pre-Deployment Afghanistan physical Activity and Injury Questionnaire

Answers should be for activities you do when you are NOT deployed. Answer for what you have done over the last four months. Circles should be completely filled in using a pen. Thank you for your participation!

Privacy Act Advisory Authority: Executive Order 9397 (SSN)
Sole use of your social security number (SSN): to retrieve information from the Armed Forces Health Surveillance Center about any muscuoskeletal diagnoses of injuries made during your deployment to Afghanistan.
Disclosure is voluntary. However, if you do not furnish your SSN, we will be unable to retrieve your deployment injury data from the theater medical data store and the data you provide will be of limited value to the study.
Once we have obtained your deployment injury data we will destroy this form and any electronic record of your SSN.
This data collection will not become part of any Privacy Act system of Records.

1. First Name

a	a	a	a	a	a	a	a	a
b	b	b	b	b	b	b	b	b
c	c	c	c	c	c	c	c	c
d	d	d	d	d	d	d	d	d
e	e	e	e	e	e	e	e	e

2. Last Name

a	a	a	a	a	a	a	a	a	a	a	a	a
b	b	b	b	b	b	b	b	b	b	b	b	b
c	c	c	c	c	c	c	c	c	c	c	c	c
d	d	d	d	d	d	d	d	d	d	d	d	d
e	e	e	e	e	e	e	e	e	e	e	e	e

f	f	f	f	f	f	f	f	f
g	g	g	g	g	g	g	g	g
h	h	h	h	h	h	h	h	h
i	i	i	i	i	i	i	i	i
j	j	j	j	j	j	j	j	j
k	k	k	k	k	k	k	k	k
l	l	l	l	l	l	l	l	l
m	m	m	m	m	m	m	m	m
n	n	n	n	n	n	n	n	n
o	o	o	o	o	o	o	o	o
p	p	p	p	p	p	p	p	p
q	q	q	q	q	q	q	q	q
r	r	r	r	r	r	r	r	r
s	s	s	s	s	s	s	s	s
t	t	t	t	t	t	t	t	t
u	u	u	u	u	u	u	u	u
v	v	v	v	v	v	v	v	v
w	w	w	w	w	w	w	w	w
x	x	x	x	x	x	x	x	x
y	y	y	y	y	y	y	y	y
z	z	z	z	z	z	z	z	z

f	f	f	f	f	f	f	f	f	f	f	f	f
g	g	g	g	g	g	g	g	g	g	g	g	g
h	h	h	h	h	h	h	h	h	h	h	h	h
i	i	i	i	i	i	i	i	i	i	i	i	i
j	j	j	j	j	j	j	j	j	j	j	j	j
k	k	k	k	k	k	k	k	k	k	k	k	k
l	l	l	l	l	l	l	l	l	l	l	l	l
m	m	m	m	m	m	m	m	m	m	m	m	m
n	n	n	n	n	n	n	n	n	n	n	n	n
o	o	o	o	o	o	o	o	o	o	o	o	o
p	p	p	p	p	p	p	p	p	p	p	p	p
q	q	q	q	q	q	q	q	q	q	q	q	q
r	r	r	r	r	r	r	r	r	r	r	r	r
s	s	s	s	s	s	s	s	s	s	s	s	s
t	t	t	t	t	t	t	t	t	t	t	t	t
u	u	u	u	u	u	u	u	u	u	u	u	u
v	v	v	v	v	v	v	v	v	v	v	v	v
w	w	w	w	w	w	w	w	w	w	w	w	w
x	x	x	x	x	x	x	x	x	x	x	x	x
y	y	y	y	y	y	y	y	y	y	y	y	y
z	z	z	z	z	z	z	z	z	z	z	z	z

3. SSN

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

4. Subject Number

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

5. Today's Date (mm/dd/yyyy)

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

6. MOS

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

7. Date of Birth (mm/dd/yyyy)

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

8. **Date You will Deploy(mm/dd/yyyy)**

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

9. Company

10. Battalion

11. Height ft in

12. Weight lbs

Enlisted	1	2	3	4	5	6	7	8	9
Officer	1	2	3	4	5	6	7	8	9
Warrant Officer	1	2	3	4	5	6	7	8	9

14. How would you rate your general health?

¡ Poor ¡ Fair ¡ Average ¡ Good ¡ Excellent

15. Are you ¡ Single ¡ Married ¡ Divorced

16. Number of dependents.

0 1 2 3 4 5 6 7 8 9

17. What is the highest level of education you have completed?

- ¡ GED
- ¡ High School
- ¡ Some college courses
- ¡ College, Bachelor Degree
- ¡ Master's Degree
- ¡ Doctorate

18. Do you smoke? ¡ YES ¡ NO **If no go to question 20.**

19. How many cigarettes do you smoke per day?

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

20. Date of last APFT

21. Current APFT Score

0 0 0
1 1 1

22. Number of Push Ups

0 0 0
1 1 1

23. Number of Sit Ups

0 0 0
1 1 1

24. Run Time (min, sec)

0 0 . 0 0
1 1 1 1

2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3		3	3	3
	4	4	4	4	4	4		4	4	4
	5	5	5	5	5	5		5	5	5
	6	6	6	6	6	6		6		6
	7	7	7	7	7	7		7		7
	8	8	8	8	8	8		8		8
	9	9	9	9	9	9		9		9

25. Have you been deployed before?

¡ YES ¡ NO

Where and when were you deployed, start with the most recent and work backwards.

1. Iraq Afghanistan ¡ Other ¡

When to when **(month/year)**?

2. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

3. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

4. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

5. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

6. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

7. Iraq ¡ Afghanistan ¡ Other ¡

When to when **(month/year)**?

26. On average, how many days per week do you work at your current duty station?

¡ Never ¡ 4 days per week
¡ 1 day per week ¡ 5 days per week
¡ 2 days per week ¡ 6 days per week
¡ 3 days per week ¡ 7 days per week

27. During the average duty day at your duty station, how many hours did you wear/carry the following

Body Armor		**Backpack of some sort**	
hours		hours	
0	0	0	0
1	1	1	1
2	2	2	2
	3		3
	4		4
	5		5
	6		6
	7		7
	8		8
	9		9

28. Which armored vest do you wear?

IOTV ¡ Plate Carrier ¡

29. During the average duty day, how much time did you spend sitting?

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

30. During the average duty day how much time did you spend standing (not walking)?

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

31. During the average duty day how much time did you spend walking (not standing)?

32 During the average duty day, how far did you walk during each duty day?

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

Miles		or Kilometers	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4		4
5	5		5
	6		6
	7		7
	8		8
	9		9

33. What was the AVERAGE load carried on your body during the duty day, including IOTV, ammo and water, all other items?

		Lbs
0	0	0
1	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9

34 What was the AVERAGE amount of time that you carried this load during the duty day?

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

35. What was the **HEAVIEST** load carried on your body during a duty day?

		Lbs
0	0	0
1	1	1

36 How long did you carry that **HEAVIEST** load on your body?

Hours		Minutes	
0	0	0	0
1	1	1	1

2	2	2	2	2	2
3	3		3	3	3
4	4		4	4	4
5	5		5	5	5
6	6		6		6
7	7		7		7
8	8		8		8
9	9		9		9

HEAVY LIFTING: This section **does not** include carrying your IOTV or other gear that you wear.
It should include activities like loading/unloading a vehicle, moving sandbags,
carrying ammo crates, stacking pallets, etc.

EXCLUDING YOUR IOTV AND STANDARD COMBAT LOAD;

37 On average, how many days per week were you required to lift and carry a heavy load? Boxes, litters, etc.

- Never (go to question 43)
- 1 day per week
- 2 days per week
- 3 days per week
- 4 day per week
- 5 days per week
- 6 days per week
- 7 days per week

38 What was the average load you were required to lift and carry?

Lbs.

0	0	0
1	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9

39. On average, how many times per day did you lift and carry this load?

- 1-2 times per day
- 3-4 times per day
- 9-10 times per day
- 5-6 times per day
- 7-8 times per day
- >10 times per day (specify times per day):

40 On average, how far were you required to carry this load?

Yards **or** Feet

0	0	0		0	0	0
1	1	1		1	1	1
2	2	2		2	2	2
3	3	3		3	3	3
4	4	4		4	4	4
5	5	5		5	5	5
6	6	6		6	6	6
7	7	7		7	7	7
8	8	8		8	8	8
9	9	9		9	9	9

41 On average, where did you pick the load up from?

¡ The Floor ¡ Knee Height ¡ Waist Height ¡ Chest Height ¡ Overhead

42 On average, how high were you required to lift this load?

¡ The Floor ¡ Knee High ¡ Waist High ¡ Chest High ¡ Overhead

ENDURANCE/CARDIO EXERCISE (These are NOT work activites. They are physical training type activities.)

43 **On average,** how many days per week did you perform cardio or endurance exercise (running, cycling, stair steppers, etc.)?

¡ Never	¡ 2 days per week	¡ 5 days per week
¡ Less than 1 day per week	¡ 3 days per week	¡ 6 days per week
¡ 1 day per week	¡ 4 days per week	¡ 7 days per week

44. On days when you performed cardio or endurance exercise, how long did you exercise, on average?

¡ None	¡ 15-30 min	¡ 46-60 min
¡ Less than 15 min	¡ 31-45 min	¡ More than 60min

STRENGTH TRAINING

45 **On average** how many days per week did you exercise to improve your strength (free weights, Cybex machines, Hammer Strength, push-ups, sit-ups, etc.)?

¡ Never	¡ 2 days per week	¡ 5 days per week

¡ Less than 1 day per week	¡ 3 days per week	¡ 6 days per week
¡ 1 day per week	¡ 4 days per week	¡ 7 days per week

46. On days when you exercised to improve your strength, how long did you exercise, on average?

¡ None	¡ 15-30 min	¡ 46-60 min
¡ Less than 15 min	¡ 31-45 min	¡ More than 60min

47. Are you currently injured?

¡ YES ¡ NO

If you CURRENTLY are injured please fill out the sections on the following pages, one page per injury you have right now.

If you have no pain or injuries now, you have finished the survey.

INJURY 1

Body Area #1 (mark one)

Head	¡	Abdomen	¡	Lower Arm	¡	Knee	¡
Face	¡	Upper Back	¡	Wrist	¡	Calf/Shin	¡
Ear	¡	Lower Back	¡	Hand	¡	Ankle	¡
Eye	¡	Shoulders	¡	Finger	¡	Foot	¡
Neck	¡	Elbow	¡	Hip	¡	Toe	¡
Chest	¡	Upper Arm	¡	Thigh	¡	Other (list)	¡

Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

Cause of Injury #1 (mark one)

Physical Training (PT)	¡	Horseplay/Rough-housing	¡
Trip/Fall	¡	Chronic(recurrent)condition	¡
Weight lifting	¡	Lifting/Carrying for Work	¡
Military Vehicle Accident	¡	Sports/Recreation (list below)	¡
Dismounted Patrol	¡		
Mounted Patrol/Convoy	¡	Other (list below)	¡

Body Armor ¡

Have you been seen by a medical professional for this condition?

Yes ¡

No ¡

Total Days of Limited Duty or Profile

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

How long have you had this condition?

Less than 1 week ¡

1-3 weeks ¡

1-3 months ¡

4-6 months ¡

7-9 months ¡

10-12 months ¡

More than 1 year ¡

INJURY 2

Body Area #2 (mark one)

Head	¡	Abdomen	¡	Lower Arm	¡	Knee	¡
Face	¡	Upper Back	¡	Wrist	¡	Calf/Shin	¡
Ear	¡	Lower Back	¡	Hand	¡	Ankle	¡
Eye	¡	Shoulders	¡	Finger	¡	Foot	¡
Neck	¡	Elbow	¡	Hip	¡	Toe	¡
Chest	¡	Upper Arm	¡	Thigh	¡	Other (list)	¡

Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

Cause of Injury #2(mark one)

Physical Training (PT)	¡	Horseplay/Rough-housing	¡
Trip/Fall	¡	Chronic(recurrent)condition	¡
Weight lifting	¡	Lifting/Carrying for Work	¡
Military Vehicle Accident	¡	Sports/Recreation (list below)	¡
Dismounted Patrol	¡		
Mounted Patrol/Convoy	¡	Other (list below)	¡
Body Armor	¡		

Have you been seen by a medical professional for this condition?

Yes ¡

No ¡

Total Days of Limited Duty or Profile

0	0	0

How long have you had this condition?

Less than 1 week ¡

1-3 weeks ¡

1	1	1	1-3 months	¡
2	2	2	4-6 months	¡
3	3	3	7-9 months	¡
4	4	4	10-12 months	¡
5	5	5	More than 1 year	¡
6	6	6		
7	7	7		
8	8	8		
9	9	9		

INJURY 3

Body Area #3 (mark one)

Head	¡	Abdomen	¡	Lower Arm	¡	Knee	¡
Face	¡	Upper Back	¡	Wrist	¡	Calf/Shin	¡
Ear	¡	Lower Back	¡	Hand	¡	Ankle	¡
Eye	¡	Shoulders	¡	Finger	¡	Foot	¡
Neck	¡	Elbow	¡	Hip	¡	Toe	¡
Chest	¡	Upper Arm	¡	Thigh	¡	Other (list)	¡

Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

Cause of Injury #3 (mark one)

Physical Training (PT)	¡	Horseplay/Rough-housing	¡
Trip/Fall	¡	Chronic(recurrent)condition	¡
Weight lifting	¡	Lifting/Carrying for Work	¡
Military Vehicle Accident	¡	Sports/Recreation (list below)	¡
Dismounted Patrol	¡		
Mounted Patrol/Convoy	¡	Other (list below)	¡
Body Armor	¡		

Have you been seen by a medical professional for this condition?

Yes ¡

No ¡

Total Days of Limited Duty or Profile

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5

How long have you had this condition?

Less than 1 week	¡
1-3 weeks	¡
1-3 months	¡
4-6 months	¡
7-9 months	¡
10-12 months	¡
More than 1 year	¡

6	6	6
7	7	7
8	8	8
9	9	9

Post Deployment Afghanistan Physical Activity and Injury Questionnaire

First Name

A	A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D	D
E	E	E	E	E	E	E	E	E
F	F	F	F	F	F	F	F	F
G	G	G	G	G	G	G	G	G
H	H	H	H	H	H	H	H	H
I	I	I	I	I	I	I	I	I
J	J	J	J	J	J	J	J	J
K	K	K	K	K	K	K	K	K
L	L	L	L	L	L	L	L	L
M	M	M	M	M	M	M	M	M
N	N	N	N	N	N	N	N	N
O	O	O	O	O	O	O	O	O
P	P	P	P	P	P	P	P	P
Q	Q	Q	Q	Q	Q	Q	Q	Q
R	R	R	R	R	R	R	R	R
S	S	S	S	S	S	S	S	S
T	T	T	T	T	T	T	T	T
U	U	U	U	U	U	U	U	U
V	V	V	V	V	V	V	V	V
W	W	W	W	W	W	W	W	W
X	X	X	X	X	X	X	X	X
Y	Y	Y	Y	Y	Y	Y	Y	Y
Z	Z	Z	Z	Z	Z	Z	Z	Z

Last Name

A	A	A	A	A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D	D	D	D	D
E	E	E	E	E	E	E	E	E	E	E	E
F	F	F	F	F	F	F	F	F	F	F	F
G	G	G	G	G	G	G	G	G	G	G	G
H	H	H	H	H	H	H	H	H	H	H	H
I	I	I	I	I	I	I	I	I	I	I	I
J	J	J	J	J	J	J	J	J	J	J	J
K	K	K	K	K	K	K	K	K	K	K	K
L	L	L	L	L	L	L	L	L	L	L	L
M	M	M	M	M	M	M	M	M	M	M	M
N	N	N	N	N	N	N	N	N	N	N	N
O	O	O	O	O	O	O	O	O	O	O	O
P	P	P	P	P	P	P	P	P	P	P	P
Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
R	R	R	R	R	R	R	R	R	R	R	R
S	S	S	S	S	S	S	S	S	S	S	S
T	T	T	T	T	T	T	T	T	T	T	T
U	U	U	U	U	U	U	U	U	U	U	U
V	V	V	V	V	V	V	V	V	V	V	V
W	W	W	W	W	W	W	W	W	W	W	W
X	X	X	X	X	X	X	X	X	X	X	X
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z

Today's Date (mm/dd/yyyy)

Please consider only the FIRST HALF of your deployment when answering questions. Thank you very much for your assistance!

Subject Number

⓪ ⓪ ⓪ ⓪ ⓪ ⓪ ⓪ ⓪ ⓪ ⓪ ⓪
① ① ① ① ① ① ① ① ① ① ①
② ② ② ② ② ② ② ② ② ② ②
③ ③ ③ ③ ③ ③ ③ ③ ③ ③
④ ④ ④ ④ ④ ④ ④ ④ ④ ④
⑤ ⑤ ⑤ ⑤ ⑤ ⑤ ⑤ ⑤ ⑤ ⑤
⑥ ⑥ ⑥ ⑥ ⑥ ⑥ ⑥ ⑥ ⑥ ⑥
⑦ ⑦ ⑦ ⑦ ⑦ ⑦ ⑦ ⑦ ⑦ ⑦
⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
⑨ ⑨ ⑨ ⑨ ⑨ ⑨ ⑨ ⑨ ⑨ ⑨

1a. **MOS**

⓪ ⓪
① ①
② ②
③ ③
④ ④
⑤ ⑤
⑥ ⑥
⑦ ⑦
⑧ ⑧
⑨ ⑨

2. How many months were you deployed for this deployment?

⓪ ⓪
① ①
②
③
④
⑤
⑥
⑦
⑧
⑨

3. Were you a member of the Female Engagement Team (FET)?

O YES O NO

4. If yes, for how many months?

⓪ ⓪
① ①
②
③
④
⑤
⑥
⑦
⑧
⑨

1b Warrant Officer

5. What is your current pay grade?

Enlisted ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Officer ① ② ③ ④ ⑤ ⑥

Warrant Officer ① ② ③ ④ ⑤

6. Are you currently ◯ Single ◯ Married ◯ Widowed ◯ Divorced

7. On average, how many days per week do you perform duty-related operations?

◯ Never ◯ 4 days per week
◯ 1 day per week ◯ 5 days per week
◯ 2 days per week ◯ 6 days per week
◯ 3 days per week ◯ 7 days per week

8. Height ☐ ft ☐ in

9. Weight ☐ ☐ lbs

10 How would you rate your general health?
◯ Poor ◯ Fair ◯ Good ◯ Excellent

11 Do you smoke? ◯ YES ◯ NO

12 Number of cigarettes per day

⓪ ⓪
① ①
② ②
③ ③
④ ④
⑤ ⑤
⑥ ⑥
⑦ ⑦
⑧ ⑧
⑨ ⑨

For the rest of the survey, answer the questions for the average amount of time you did the activity or weight you carried <u>BEFORE</u> your first injury.

13 In your own words, what was your primary duty? (What did you do for work most days?)

14 If you had to categorize your primary duty what would you say it was? (pick one)

◯ Working indoors ◯ Lifting and carrying things on the FOB ◯ Mechanic/Repairs
◯ Riding in vehicles ◯ Working off the FOB ◯ Guard detail

15 Which body armor did you wear?

○ IOTV ○ Plate Carrier ○ IBA ○ Female IOTV (101st only)

16 During the AVERAGE duty day, how many hours did you wear/carry the following

Body Armor		**Backpack of some sort**	
hours		hours	
0	0	0	0
1	1	1	1
	2		2
	3		3
	4		4
	5		5
	6		6
	7		7
	8		8
	9		9

17 During the AVERAGE duty day, how many hours did you spend sitting?

Hours		Minutes	
0	0	0	0
1	1	1	1
	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7

18. During the AVERAGE duty day how much time did you spend standing (not walking)?

Hours		Minutes	
0	0	0	0
1	1	1	1
	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7

⑧ ⑧ ⑧ ⑧
⑨ ⑨ ⑨ ⑨

19 During the AVERAGE duty day how much time did you spend walking (not standing)?

Hours Minutes

Hours		Minutes	
0	0	0	0
1	1	1	1
	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

20. During the AVERAGE duty day, how far did you walk during each day?

Miles

Miles	
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

21 What was the AVERAGE load worn on your body during the duty day, including body armor, ammo and water, all other items? (in pounds)

lbs

lbs	
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

22. What was the AVERAGE amount of time that you wore this load during the duty day?

Hours Minutes

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2
	3	3	3
	4	4	4
	5	5	5
	6		6
	7		7
	8		8
	9		9

23 What was the **HEAVIEST** load worn on your body during a duty day? (in pounds)

lbs

lbs		
0	0	0
1	1	1
2	2	2

24. How long did you wear that **HEAVIEST** load on your body?

Hours Minutes

Hours		Minutes	
0	0	0	0
1	1	1	1
2	2	2	2

HEAVY LIFTING: This section **does NOT** include carrying your body armor or other gear that you wear. It includes activities like loading/unloading a vehicle, moving sandbags, lifting boxes, lifting litters, carrying ammo crates, stacking pallets, etc.

EXCLUDING YOUR IOTV AND STANDARD COMBAT LOAD;

25 On average, how many days per week were you required to lift up and carry a heavy load? Boxes, litters, etc.

- ◯ Never (go to next page)
- ◯ 1 day per week
- ◯ 2 days per week
- ◯ 3 days per week
- ◯ 4 day per week
- ◯ 5 days per week
- ◯ 6 days per week
- ◯ 7 days per week

26. What was the average load you were required to lift and carry (in pounds)

lbs

27 On average, how many times per day did you lift and carry this load?

times/day

28 On average, how far were you required to carry this load?

Feet **OR** Yards

⓪ ⓪ ⓪	⓪ ⓪ ⓪
① ① ①	① ① ①
② ② ②	② ② ②
③ ③ ③	③ ③ ③
④ ④ ④	④ ④ ④
⑤ ⑤ ⑤	⑤ ⑤ ⑤
⑥ ⑥ ⑥	⑥ ⑥ ⑥
⑦ ⑦ ⑦	⑦ ⑦ ⑦
⑧ ⑧ ⑧	⑧ ⑧ ⑧
⑨ ⑨ ⑨	⑨ ⑨ ⑨

29 On average where did you pick the load up from?

◯ The Floor ◯ Knee Height ◯ Waist Height ◯ Chest Height ◯ Overhead

30 On average, how high were you required to lift this load?

◯ The Floor ◯ Knee High ◯ Waist High ◯ Chest High ◯ Overhead

Injuries during Deployment: include injuries that are acute (sudden and unexpected) and those caused by using the body too much (pain that develops over time). An injury is pain to a muscle, joint, bone, or nerve lasting on and off for greater than 24 hours that made it more difficult to work or do physical training. If you had the injury as you deployed do not list it (it occurred in the US). If you have had it before but it was completely healed before deploying and you re-injured it during deployment you can include that.

31. How many injuries did you have during the deployment?

injuries (if none, you are finished)

⓪ ⓪
① ①
② ②
③ ③
④ ④
⑤ ⑤
⑥ ⑥
⑦ ⑦

⑧ ⑧
⑨ ⑨

INJURY 1

32 When did the injury happen? Year__________

- ◯ January
- ◯ February
- ◯ March
- ◯ April
- ◯ May
- ◯ June
- ◯ July
- ◯ August
- ◯ September
- ◯ October
- ◯ November
- ◯ December

33 How long did you have this condition (or episode)?

- ◯ Less than 1 week
- ◯ 1-3 weeks
- ◯ 1-3 months
- ◯ 4-6 months
- ◯ 7-9 months

34 Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

☐

35. Cause of Injury #1 (mark one)

Physical Training (PT)	◯	Horseplay/Rough-housing	◯
Trip/Fall	◯	Chronic(recurrent)condition	◯
Weight lifting (in the "gym")	◯	Lifting/Carrying for Work	◯
Military Vehicle Accident	◯	Sports/Recreation (list below)	◯
Dismounted Patrol	◯		
Mounted Patrol/Convoy	◯	Other (list below)	◯
Body Armor	◯		

36
- ◯ This is a new injury that occurred for the first time during the deployment
- ◯ This is a re-injury of an injury I had before deploying but no longer hurt until I deployed and re-injured it

37 Please tell me in your own words how you got hurt.

38 Did you get hurt while doing FET activities? ◯ Yes ◯ No

39 Did the injury limit your ability to do your job?

◯ A lot ◯ Moderately ◯ A little ◯ Not at all

40 Did another Soldier have to do your main job because you could not due to your injury? ◯ Yes ◯ No

41 Did the injury limit your ability to do PT?

- ◯ A lot
- ◯ Moderately
- ◯ A little
- ◯ Not at all

42 Total number of days the injury stopped you from completely doing your job or PT. (limited duty days)

⓪ ⓪ ① ① ② ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

43 Have you been seen by a medical professional for this condition?

- ◯ Yes
- ◯ No

44 What was the body area you injured the most for the 1st injury? (mark one)

◯ Head	◯ Abdomen	◯ Lower Arm	◯ Knee
◯ Face	◯ Upper Back	◯ Wrist	◯ Calf/Shin
◯ Ear	◯ Lower Back	◯ Hand	◯ Ankle
◯ Eye	◯ Shoulders	◯ Finger	◯ Foot
◯ Neck	◯ Elbow	◯ Hip	◯ Toe
◯ Chest	◯ Upper Arm	◯ Thigh	◯ Other (list)_______________

45 Did this injury occur while ◯ On Duty ◯ Off Duty ◯ On Leave

INJURY 2

46 When did the injury happen? Year_____________

◯ January	◯ July
◯ February	◯ August
◯ March	◯ September
◯ April	◯ October
◯ May	◯ November
◯ June	◯ December

47. How long did you have this condition (or episode)?

- ◯ Less than 1 week
- ◯ 1-3 weeks
- ◯ 1-3 months
- ◯ 4-6 months
- ◯ 7-9 months

48 Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

☐

49 Cause of Injury #2(mark one)

Physical Training (PT) ◯	Horseplay/Rough-housing ◯
Trip/Fall ◯	Chronic(recurrent) condition ◯
Weight lifting (in the "gym") ◯	Lifting/Carrying for Work ◯
Military Vehicle Accident ◯	Sports/Recreation (list below) ◯
Dismounted Patrol ◯	

Mounted Patrol/Convoy ◯ Other (list below) ◯
Body Armor ◯

50 ◯ This is a new injury that occurred for the first time during the deployment
◯ This is a re-injury of an injury I had before deploying but no longer hurt until I deployed and re-injured it

51 Please tell me in your own words how you got hurt.

52 Did you get hurt while doing FET activities? ◯ Yes ◯ No

53 Did the injury limit your ability to do your job?
◯ A lot ◯ Moderately ◯ A little ◯ Not at all

54 Did another Soldier have to do your main job because you could not due to your injury? ◯ Yes ◯ No

55 Did the injury limit your ability to do PT?
◯ A lot ◯ Moderately
◯ A little ◯ Not at all

56 Total number of days the injury stopped you from completely doing your job or PT. (limited duty days)

⓪	⓪	⓪
①	①	①
②	②	②
	③	③
	④	④
	⑤	⑤
	⑥	⑥
	⑦	⑦
	⑧	⑧
	⑨	⑨

57 Have you been seen by a medical professional for this condition?
◯ Yes ◯ No

58 What was the body area you injured the most for the 2nd injury? (mark one)

◯ Head	◯ Abdomen	☐ Lower Arm	◯ Knee
◯ Face	◯ Upper Back	☐ Wrist	◯ Calf/Shin
◯ Ear	◯ Lower Back	☐ Hand	◯ Ankle
◯ Eye	◯ Shoulders	☐ Finger	◯ Foot
◯ Neck	◯ Elbow	☐ Hip	◯ Toe
◯ Chest	◯ Upper Arm	☐ Thigh	◯ Other (list)_______________

59 Did this injury occur while ◯ On Duty ◯ Off Duty ◯ On Leave

INJURY 3

60 When did the injury happen? Year_____________

◯ January	◯ July
◯ February	◯ August
◯ March	◯ September
◯ April	◯ October
◯ May	◯ November

61. How long did you have this condition (or episode)?
◯ Less than 1 week
◯ 1-3 weeks
◯ 1-3 months
◯ 4-6 months

○ June ○ December ○ 7-9 months

62 Specifically, what is the injury? If you know the diagnosis please list it here, if you do not know the diagnosis please explain the injury in your own words.

63 Cause of Injury #3(mark one)

Physical Training (PT)	○	Horseplay/Rough-housing	○
Trip/Fall	○	Chronic(recurrent)condition	○
Weight lifting (in the "gym")	○	Lifting/Carrying for Work	○
Military Vehicle Accident	○	Sports/Recreation (list below)	○
Dismounted Patrol	○		
Mounted Patrol/Convoy	○	Other (list below)	○
Body Armor	○		

64
○ This is a new injury that occurred for the first time during the deployment
○ This is a re-injury of an injury I had before deploying but no longer hurt until I deployed and re-injured it

65 Please tell me in your own words how you got hurt.

66 Did you get hurt while doing FET activities? ○ Yes ○ No

67 Did the injury limit your ability to do your job?
○ A lot ○ Moderately ○ A little ○ Not at all

68 Did another Soldier have to do your main job because you could not due to your injury? ○ Yes ○ No

69 Did the injury limit your ability to do PT?
○ A lot ○ Moderately
○ A little ○ Not at all

70 Total number of days the injury stopped you from completely doing your job or PT. (limited duty days)

⓪ ⓪
① ①
② ②
③
④

71 Have you been seen by a medical professional for this condition?
○ Yes ○ No

72 What was the body area you injured the most for the 3rd injury? (mark one)

○ Head	○ Abdomen	○ Lower Arm	○ Knee
○ Face	○ Upper Back	○ Wrist	○ Calf/Shin
○ Ear	○ Lower Back	○ Hand	○ Ankle

◯ Eye	◯ Shoulders	◯ Finger	◯ Foot	⑤
◯ Neck	◯ Elbow	◯ Hip	◯ Toe	⑥
◯ Chest	◯ Upper Arm	◯ Thigh	◯ Other (list)_______________	⑦
				⑧

73 Did this injury occur while : ◯ On Duty ◯ Off Duty ◯ On Leave ⑨

APPENDIX B

PITTSBURGH SLEEP QUALITY INDEX

Pre-Deployment PSQI

Instructions:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

Bed Time________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

Number of Minutes___________

3. During the past month, what time have you usually gotten up in the morning?

Getting Up Time______________

4. During the past month, how many hours of actual sleep did you get a night? (This may be different than the number of hours you spent in bed.)

Hours of Sleep per Night____________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

b) Wake up in the middle of the night or early morning

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

c) Have to get up to use the bathroom

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

e) Cough or snore loudly

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

f) Feel too cold

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

g) Feel too hot

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

h) Had bad dreams

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

i) Have pain

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

j) Other reason(s), please describe____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

6. During the past month, how would you rate your sleep quality overall?

Very good___ Fairly good___ Fairly bad____ Very bad_____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or over the counter)?

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

8. During the past month, how often have you had trouble staying awake while driving, eating, meals, or engaging in social activity?

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a week______

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all___ Only a slight problem__ Somewhat of a problem__ A very big problem_

10. Do you have a bed partner or roommate?

No bed partner or roommate__ Partner/roommate in other room__ Partner in same room, but not same bed__ Partner in same bed____

If you have a roommate or bed partner, ask him/her how often in the past month you have had . .

a) Loud snoring

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a a week______

b) Long pauses between breaths while asleep

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a a week______

c) Legs twitching or jerking while you sleep

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a a week______

d) Episodes of disorientation or confusion during sleep

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a a week______

e) Other restlessness while you sleep; please describe___________________________________

Not during the past month_____ Less than once a week ________ Once or twice a week ------------- Three or more times a a week______

Post Deployment PSQI

Instructions:

The following questions relate to your usual sleep habits during deployment. If you were injured, answer for the time BEFORE you were injured. If you were not injured simply select answers relative to your time deployed. Your answers should indicate the most accurate reply for the majority of days and nights while deployed prior to injury, NOT once you returned home. Please answer all questions.

1. During deployment, what time have you usually gone to bed at night?

Bed Time________

2. During deployment, how long (in minutes) has it usually taken you to fall asleep each night?

Number of Minutes___________

3. During the deployment, what time have you usually gotten up in the morning?

Getting Up Time______________

4. During deployment, how many hours of actual sleep did you get a night? (This may be different than the number of hours you spent in bed.)

Hours of Sleep per Night____________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During deployment, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

b) Wake up in the middle of the night or early morning

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

c) Have to get up to use the bathroom

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

d) Cannot breathe comfortably

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

e) Cough or snore loudly

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

f) Feel too cold

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

g) Feel too hot

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

h) Had bad dreams

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

i) Have pain

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

j) Other reason(s), please describe____

How often during deployment have you had trouble sleeping because of this?

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

6. During deployment, how would you rate your sleep quality overall?

Very good___ Fairly good___ Fairly bad____ Very bad_____

7. During deployment, how often have you taken medicine to help you sleep (prescribed or over the counter)?

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

8. During deployment, how often have you had trouble staying awake while driving, eating, meals, or engaging in social activity?

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

9. During deployment, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all___ Only a slight problem__ Somewhat of a problem__ A very big problem__

10. Do you have a bed partner or roommate?

No bed partner or roommate__ Partner/roommate in other room__ Partner in same room, but not same bed__ Partner in same bed____

If you have a roommate or bed partner, ask him/her how often during deployment you have had .

a) Loud snoring

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

b) Long pauses between breaths while asleep

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

c) Legs twitching or jerking while you sleep

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

d) Episodes of disorientation or confusion during sleep

Never__ Less than once a week__ Once or twice a week__ Three or more times a week__

e) Other restlessness while you sleep; please describe________________________________

APPENDIX C

JOB CONTENT QUESTIONNAIRE-14

Pre-Deployment JCQ-14 instructions. Please answer the following questions about how you have felt over the last 6 months by choosing the bubble with the answer that comes closest to describing your current situation.

Post Deployment JCQ-14 instructions. Please answer the following questions about how you have felt over the deployment. If you had an injury, choose answers for this questionnaire based on what you felt during the deployment BEFORE you were injured. If you were not injured, simply choose answers based on what you felt during the deployment. Choose the bubble with the answer that comes closest to describing your situation.

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. My job requires working very fast.	①	②	③	④
2. My job requires working very hard.	①	②	③	④
3. I am not asked to do an excessive amount of work on my job.	①	②	③	④
4. I have enough time to get my job done.	①	②	③	④
5. In my job I am free from conflicting demands that others make.	①	②	③	④

6. My job requires that I learn new things.	①	②	③	④
7. My job involves a lot of repetitive work.	①	②	③	④
8. My job requires me to be creative.	①	②	③	④
9. My job allows me to make a lot of decisions on my own.	①	②	③	④
10. My job requires a high level of skill.	①	②	③	④
11. On my job I have very little freedom to decide how I do my work.	①	②	③	④
12. I get to do a variety of different things on my job.	①	②	③	④
13. I have a lot to say about what happens on my job.	①	②	③	④
14. I have the opportunity to develop my own special abilities on my job.	①	②	③	④

APPENDIX D

BRIEF COPE

Pre-Deployment Brief Cope instructions. These items deal with ways you've been coping with the stress in your life. There are many ways to try to deal with problems. These items ask what you've been doing to cope with this one. Obviously, different people deal with things in different ways, but I'm interested in how you've tried to deal with it. Each item says something about a particular way of coping. I want to know to what extent you've been doing what the item says. How much or how frequently. Don't answer on the basis of whether it seems to be working or not—just whether or not you're doing it. Use these response choices. Try to rate each item separately in your mind from the others. Make your answers as true FOR YOU as you can.

Post Deployment Brief Cope instructions. These items deal with ways you've been coping with the stress in your life. There are many ways to try to deal with problems. These items ask what you've been doing to cope with this one. Obviously, different people deal with things in different ways, but I'm interested in how you've tried to deal with it. Each item says something about a particular way of coping. I want to know to what extent you've been doing what the item says. How much or how frequently. Don't answer on the basis of whether it seems to be working or not—just whether or not you're doing it. Use these response choices. Try to rate each item separately in your mind from the others. Make your answers as true FOR YOU as you can.

If you had an injury, choose answers for this questionnaire based on what you were doing during the deployment BEFORE you were injured. If you were not injured, simply choose answers based on what you were doing during the deployment.

	I haven't been doing this at all	I've been doing this a little bit	I've been doing this a medium amount	I've been doing this a lot
1. I've been turning to work or other activities to take my mind off things.	①	②	③	④
2. I've been concentrating my efforts on doing something about the situation I'm in.	①	②	③	④
3. I've been saying to myself "this isn't real."	①	②	③	④
4. I've been using alcohol or other drugs to make myself feel better.	①	②	③	④
5. I've been getting emotional support from others.	①	②	③	④
6. I've been giving up trying to deal with it.	①	②	③	④
7. I've been taking action to try to make the situation better.	①	②	③	④
8. I've been refusing to believe that it has happened.	①	②	③	④
9. I've been saying things to let my unpleasant feelings escape.	①	②	③	④
10. I've been getting help and advice from other people.	①	②	③	④
11. I've been using alcohol or other drugs to help me get through it.	①	②	③	④

	I haven't been doing this at all	I've been doing this a little bit	I've been doing this a medium amount	I've been doing this a lot
12. I've been trying to see it in a different light, to make it seem more positive.	①	②	③	④
13. I've been criticizing myself.	①	②	③	④
14. I've been trying to come up with a strategy about what to do.	①	②	③	④
15. I've been getting comfort and understanding from someone.	①	②	③	④
16. I've been giving up the attempt to cope.	①	②	③	④
17. I've been looking for something good in what is happening.	①	②	③	④
18. I've been making jokes about it.	①	②	③	④
19. I've been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping, or shopping.	①	②	③	④
20. I've been accepting the reality of the fact that it has happened.	①	②	③	④
21. I've been expressing my negative feelings.	①	②	③	④
22. I've been trying to find comfort in my religion or spiritual beliefs.	①	②	③	④
23. I've been trying to get advice or help from other people about what to do.	①	②	③	④
24. I've been learning to live with it.	①	②	③	④
25. I've been thinking hard about what steps to take.	①	②	③	④
26. I've been blaming myself for things that happened.	①	②	③	④
27. I've been praying or meditating.	①	②	③	④
28. I've been making fun of the situation.	①	②	③	④

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