Prevention and Rehabilitation of Musculoskeletal Injuries During Military Operations and Training

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Abstract

Zambraski, EJ and Yancosek, KE. Prevention and rehabilitation of musculoskeletal injuries during military operations and training. J Strength Cond Res 26(7): S101–S106, 2012—Injuries are a major impacting factor for a military organization. Injuries may be the result of direct combat, or noncombat, and may be incurred during deployment, other military operations, and training. The impact of injuries is the loss of manpower (e.g., lost duty days), medical costs for treatment, and the influence that an injury may have on an individual’s quality of life. To address this issue, it is essential to understand the types of injuries that are occurring, and the mechanisms responsible for those injuries, to develop strategies to reduce injury incidence and to allocate the resources required for rehabilitation to return the individual to duty. This article will review the most common medical injury being incurred by our present warfighter; namely, musculoskeletal injuries (MSIs). The number, types, and causal mechanisms of MSIs will be reviewed. Risk factors for MSIs will be identified and the various interventions being used to prevent or mitigate the severity of MSIs will be discussed. Lastly, the programs that have been developed within the U.S. Department of Defense and the U.S. Army for the assessment, care, and rehabilitation of the most severe MSIs incurred while deployed will be described.

Key Words musculoskeletal, rehabilitation, injury prevention, military

Introduction

Scope of the Musculoskeletal Injury Problem

Musculoskeletal injuries (MSIs) include a broad array of medical conditions involving muscle, tendon, nerve, ligament, and bone tissue. The injuries may occur acutely (trauma), or result from repetitive stress (overuse), which tend to be episodic, recurrent, and potentially advance into chronic conditions. Such injuries may include muscle strains, contusions, tendinopathy, fasciitis, bursitis, muscle and tendon tears and ruptures, joint sprains, ligament tears, joint dislocation, bone fractures, cartilaginous damage, and bone stress fractures.

The Department of Defense maintains an extensive electronic medical records system. Service members’ medical data are captured regardless of whether they are treated at a Military Treatment Facility as an inpatient, or in an outpatient setting. Within the Department of Defense, there are medical surveillance organizations. Examples are the “U.S. Army Public Health Command” and the “Armed Forces Health Surveillance Center” (AFHSC). The AFHSC maintains the Defense Medical Epidemiology Database that captures records of nondeployed service members and other specialized databases that have been established to monitor medical encounters during deployments. Lastly, the U.S. Army has established the “Total Army Health Outcomes Database” (TAIHOD). The TAIHOD contains all of the medical data on every soldier from approximately 1985 to the present (2). These various resources are used to track all medical problems, including MSI.

Jones et al. (21) reported that MSI were the leading cause for all medical encounters (>1.95 million) in 2006 for all of the US military. The MSI medical encounters were 2–3 times greater than the next leading category (mental disorders). In 2010, the AFHSC reported that MSIs of deployed and nondeployed service members were responsible for the greatest number of medical encounters (30%) (3). The next leading cause of medical encounters (15%), were mental disorders. Within the U.S. Army, over a 20-year period (1980–2002), the medical disability discharge rates increased sevenfold to eightfold, with MSIs being responsible for approximately 70% of these discharges (5). Mental health and neurological types of disability combined were responsible for 11% of these cases.

Cohen et al. (8) examined the medical evacuations from Iraq and Afghanistan over a 3-year period (2004–2007). There were 34,006 personnel medically evacuated. The most common reason for evacuation (24%) was for noncombat MSI injuries. Noncombat injuries were defined as injuries.
not caused by the enemy but do include injuries incurred while in the operational or battle environment. Combat injuries were responsible for 14% of these evacuations. A U.S. Army Brigade Combat Team (n = 4,122), deployed to Iraq, had 1,324 nonbattle injuries (6). The MSI injuries accounted for 50% of these injuries.

The MSIs are also extremely high in Army recruits while they undergo the 8–9 weeks of their initial Basic Combat Training (BCT). A study by Bell et al. (4) reported that 27% of men and 57% of women experienced ≥1 injuries during BCT. Knapik et al. (24) reported an injury incidence rate of 0.56 and 1.16/100 person days for men and women respectively, completing BCT. These high injury rates during BCT may result in delay of graduation, and in many cases, attrition or withdrawal from military service.

A study was done to investigate deployment readiness of 158 soldiers with orthopedic injuries (10). The study tracked the injured soldiers 3 months before and throughout deployment to Iraq. Despite compliance with rehabilitation services, 99 soldiers (62.7%) were unable to deploy, or even meet up later, with the unit; 35 soldiers were able to deploy on time; and 6 soldiers joined the unit within 3 months of the initial deployment date. Further analysis of results revealed that (a) soldiers with spinal injuries were the most recalcitrant to rehabilitation and therefore more likely to remain non-deployable and (b) behavioral health and other health concerns became secondary problems prohibiting deployment, despite recovery from original orthopedic condition.

Studies have also characterized the location and types of MSIs. For the entire military, across all services, spine or back and injuries of the lower extremities each account for 40% of the MSIs; 80% of the total (13). Upper extremity injuries represent only 14% of the total. These results are similar to the injury locations associated with BCT. The AFHSC data document that back and abdominal and lower extremity injuries also predominate as the major sites of MSIs in deployed troops. A recent study by Roy (30) documented the diagnoses and locations of injuries within an Infantry Brigade Combat Team deployed to Afghanistan over a 15-month period. The most common diagnosed MSIs were mechanical low back pain (19.4%), with ankle sprain at 11.6% and knee pain at 4.3%. Information on the body regions being injured indicated that the greatest number of cases involved the spine (30.7%), with 70% of those being in the lumbar region. The MSIs at the knee and ankle accounted a similar percentage of the total injury sites (31.5%) (31).

**Identified Risk Factors**

Several major risk factors for MSIs have been identified. These are listed in Table 1. It is clear that some of these factors are amenable to change, such as running mileage, aerobic fitness level, and smoking. Of these factors, the most impacting in the military setting is gender because, on average, women in BCT have significantly higher MSIs than do men. However, an extremely important finding is that if one compares a group of highly fit females, with the same maximal oxygen consumption as the men, the injury levels are similar. Consequently, the increased incidence of MSIs in women appears to be because of aerobic fitness and not gender per se.

![Table 1. Risk factors with strong supporting evidence for musculoskeletal injuries within the military.*](image)

<table>
<thead>
<tr>
<th>Risk factors</th>
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<tr>
<td>Female gender</td>
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<tr>
<td>High running mileage</td>
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<tr>
<td>Low aerobic fitness and endurance</td>
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<tr>
<td>Extremes in flexibility</td>
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<tr>
<td>Prior injury</td>
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<tr>
<td>Participation in recreational sports activities</td>
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<tr>
<td>Cigarette smoking</td>
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<tr>
<td>Limited history of prior physical activity</td>
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<td>Age of running shoes</td>
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*Information derived from (7,14).

One injury risk factor that has an amplified negative effect on MSIs within the military is having a previous injury (20,23). Individuals with a prior ankle sprain have a 30–50% greater probability of having a repeat lower extremity injury (36). Data from the TAIHOD have shown that a prior knee injury results in a 7- to 10-fold increase in the likelihood of a subsequent knee injury (17). It is important to note that many of these repetitive injuries are location or site specific, suggesting that there may be a direct causal link between the 2 injuries. Also, the reinjury issue could be that an individual may have a certain general predisposition for MSI (e.g., low aerobic fitness). The implication of this finding is that the high level of injury seen in the BCT environment are responsible for, or significantly increase, the chance of MSIs later in the career of a service member. Consequently, one of the most important places to try and mitigate MSIs is within BCT.

Two studies have examined MSI rates in soldiers in Advanced Individual Training (AIT) (12,15). The more recent study explored injury risk factors of soldiers enrolled in AIT at Aberdeen Proving Ground (12). Results showed time-loss injury incidences of 31% (men) and 54% (women). Race, slower 2-mile run times, and self-reported injury were risk factors for both men and women. Native American race was associated with injuries among men and white race for women. Additionally, results showed that lower sit-up performance on the Army Physical Fitness Test and a history of smoking were risk factors for men. To reduce MSI incidence rates at AIT, the authors suggested smoking cessation instructions and prearmy conditioning programs.

With tens of thousands of service members currently deployed, and millions of soldiers who have been deployed, and the high number of noncombat MSIs occurring in theater, attempts have been made to identify risk factors for MSIs
that are associated with the battlefield activities or demands of deployment (33). Recently, it was reported that the hours per day wearing body armor, the weight of the equipment carried (i.e., load carriage) and the miles walked per day were all significantly correlated to the incidence of MSIs during deployment (31).

One identified risk factor associated with early discharge from military service is a high body mass index (BMI) (28). A recent study by Packnett et al. (27) demonstrated a "U shaped" pattern for the relationship of BMI to medical discharge from the U.S. Army. Those individuals with the highest and lowest BMIs were more likely to leave the service.

One of the most severe MSIs is rhabdomyolysis, which is a complete destruction of muscle tissue. Rhabdomyolysis, if severe enough, may lead to kidney failure and death. Rhabdomyolysis is higher in service members as compared with the civilian population. Recent epidemiological studies of rhabdomyolysis in the military have shown that it is most likely to occur in soldiers with <90 days of service (e.g., in or shortly after BCT) (15). Another key finding is that a soldier who has had any kind of prior heat injury (heat cramps, heat exhaustion or heat stroke) is 22-fold more likely to experience rhabdomyolysis (18).

Prevention of Musculoskeletal Injuries

Although the prevention of MSIs is important in the military setting, historically, there has been a significant interest in MSI prevention strategies in both the military and civilian environments. Many injury prevention measures currently used are traditional, anecdotal or teleological (i.e., this makes sense; therefore, it must be true). Only in the last few years has a concerted effort been made to validate effective MSI prevention measures. These efforts have been supported largely by military organizations. Two recently published reviews have evaluated the level and strength of research evidence to support the effectiveness of a given intervention to reduce MSIs (7,14). What is surprising is that many “traditional” measures believed to reduce MSIs are not supported by the actual research that has been done. Examples are stretching, warming-up, the type and age of running shoes, and targeted muscle strengthening (Table 2).

Prevention of MSIs is a top priority of the Army Medical Department; however, there are several challenges surrounding most prevention strategies. Challenges include the reality that military operations are inherently dangerous and demanding. Success on the battlefield is predicated on highly trained soldiers who have undergone intense, realistic training to be physically and mentally prepared to execute myriad missions. Additionally, the operational tempo of combat requires sustained performance over several months often in austere environments. Sustained military operations create scenarios of altered sleep cycles, restricted caloric intake, and periods of extremely heavy work. These demands have physiological consequences of decremented anabolic hormones, increase in catabolic hormones, loss of skeletal muscle and bone (16,26). Because of the limitations in completely diminishing the risks of MSI intrinsic to military occupations, prevention strategies to mitigate MSIs are divided into 2 categories: (a) training and (b) operational.

Prevention Strategies in Nonoperational Environments

Prevention strategies in the training environment are less constrained than prevention in the operational environment; however, realistic training means soldiers should have exposure (albeit controlled) to risk factors such wearing body armor, carrying heavy loads, sustaining heavy manual labor, and walking and running (foot patrols) on uneven terrain. To examine strategies to prevent avoidable injuries in training, army researchers must work with commanders to compare training scenarios and schedules while controlling for confounding variables. Although resource intensive and logistically difficult to undertake, comparative studies are the best way to discover answers to a question such as, “What type and amount of training is needed to adequately prepare soldiers for success on the battlefield without causing injury from overtraining?”

<table>
<thead>
<tr>
<th>TABLE 2. Interventions aimed at reducing musculoskeletal injuries.*</th>
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<tr>
<td><strong>Interventions with strong evidence</strong></td>
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<tr>
<td>Reduction in running frequency, duration, and distance</td>
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<tr>
<td>Training that includes neuromuscular, proprioception, and agility activities</td>
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<tr>
<td>Wearing mouth guards</td>
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<tr>
<td>Use of ankle braces for high risk activities</td>
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<td>Improved aerobic fitness</td>
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*Information derived from (7,14).
These results have changed the doctrine and practices within the U.S. military. There is a widespread concerted effort to decrease running mileage to decrease overtraining or overuse MSIs. The U.S. Army has modified its physical fitness training program with “Physical Readiness Training” (PRT) (22). This new training program incorporates many of the scientific principles for effective training and injury prevention such as progressive overload, variety of exercises, and the inclusion of proprioception-balance-agility components. Initial studies suggest that this new physical readiness training (PRT) decreases injuries when compared to the traditional Army fitness programs.

The U.S. Army Medical Command initiated Musculoskeletal Action Teams (MATs) to reduce the burden of MSIs. The MATs consist of physical therapists, athletic trainers, and physical therapy assistants to work with military recruits to tolerate strenuous activity in the training environment. The MAT personnel also teach resiliency to stress, nutritional and dietary wellness, and how to recover from arduous training (37).

A final, and perceivably unpopular, prevention strategy within the training environment is to reduce the number of sports injuries, which account for a large number of MSIs in service members. Approximately 20% of the noncombat injuries may be because of recreational sports (33,35). Preventing sports injuries is possible with stricter management of recreational activities, such as not permitting inexperienced soldiers to engage in unfamiliar sports, rotating players, and prohibiting unrefereed games. There is an obvious trade-off of losses here: the lost benefit of morale building through sport engagement versus the reduced risk for duty days lost to recovery time of probable MSIs. Commanders and leaders at all levels need to be properly informed about incidence rates of MSIs caused by sporting activities so they can calculate their risks and make informed decisions based on the needs of their unit.

Recently, an important intervention was evaluated to decrease bone stress fractures in military recruits. Over 5,000 healthy female Navy recruits were given 200 mg of CA++ and 800 IU of Vitamin D during 8 weeks of recruit training. Compared with the placebo group, the group receiving the supplementation decreased stress fractures by 20% (25).

**Prevention Strategies in Operational Environments**

Given the intense nature of combat, prevention strategies in the operational environment are often more idealistic than practical.

To target improved whole-body health through nutrition, the Army developed the First Strike Ration, a light portion with essential nutrients to sustain performance and maintain energy for short (3- to 7-day) combat missions (9). Besides keeping soldiers well nourished in the operational environment, the number one strategy to deal with MSIs is to provide early access to rehabilitation services.

**Rehabilitation Services in Theater**

Currently, in theater, there are 33 and 43 physical and occupational therapists, respectively.

The medical and operational benefits of having rehabilitation services in theater have long been recognized, because therapists are a vital component to medical and rehabilitation care teams (11,29). Physical and occupational therapists in the Army obtain an additional skill identifier as a “physician extender,” specifically serving as neuromusculoskeletal screeners thereby allowing orthopedic doctors to attend, namely, to surgical cases (1,19).

Medical benefits of rehabilitation services in theater include providing early MSI diagnosis and treatment; establishing a “positive expectancy” for recovery; identifying injury trends for higher commands to prevent injury patterns; and managing non-emergent patients “close to the fight.” A perceived downside to positioning rehabilitation assets so close to the fight relates to the increased pressure (from soldiers and commanders) to quickly return a soldier to duty. A potentially premature return to highly demanding combat operations creates immediate reexposure to risk factors such as extreme load carriage burdens, continual physical stress, and probable disrupted sleep cycles. Furthermore, high operational tempo creates a sustained level of stress throughout deployment that likely affects healing rates and contributes to reinjury risk.

The operational benefits of therapy services organic to units in theater include sustaining

![Figure 1. Rehabilitation team members who address musculoskeletal injuries in deployed environment.](image-url)
unit personnel strength; maintaining unit cohesion during deployment; setting a proactive tone for reporting injuries and seeking immediate diagnosis and rehabilitation; and, boosting soldiers’ confidence in military leaders and the medical system which then improves morale. The operational downside to having therapists in theater is that the units are forced to carry out missions with fewer soldiers as they wait for recovering service members. The reduction in the strength of the fighting force results because a unit commander cannot request a replacement soldier unless the injured one is medically evacuated out of the theater of operations.

Because occupational and physical therapists contribute to making medical decisions about return to duty, the risk of reinjury with returning a previously injured (and presumed healed) soldier back to unrestricted duty must be calculated. An injured soldier needs time to heal properly before returning to the performance level expected of full duty status. The number one predictor of reinjury is previous injury, and ignoring this critical risk factor invites the following potential cascade of events: chronicity, permanent disability, failure to perform one’s military duties or responsibilities, and ultimately medical discharge from the military. See Figure 1 for diagram of team members who decide about an injured soldier’s medical disposition.

To assist medical providers in the decision making process and to prevent acute MSIs from advancing to chronic conditions through proper management, the Army Medical Department created a musculoskeletal screening and referral toolbox, available at https://www.qmo.amedd.army.mil/srts/SRTHTM. When a soldier experiences severe MSIs that will require extensive surgery or is sustained from direct combat exposure, he or she is evacuated from the theater of operations. The soldier is then assigned to a Warrior Transition Unit and receives therapy (and other) services in a military medical center.

Rehabilitation After Aeromedical Evacuation

Soldiers evacuated out of theater generally have significant concomitant injuries such as traumatic brain injury, burns, amputation, ocular injury, and behavioral health issues (34). Soldiers with multiple complex injuries (polytrauma) have led to the establishment of specialized rehabilitation programs and facilities (38) such as the Center for the Intrepid in San Antonio, TX; the Military Advanced Training Center in Washington, DC, and the Comprehensive Combat and Complex Casualty Care (C5) at the Naval Medical Center in San Diego, CA.

Conclusions

Musculoskeletal injuries are the number one medical problem eroding military readiness. The MSIs cost hundreds of million dollars annually and millions of lost and limited duty days among service members (32). The U.S. Department of Defense has made a strong commitment to decrease the number and severity of MSIs in the U.S. military through an investment in research to identify risk factors and to validate MSI prevention interventions. These scientific findings are changing practices and policies within the Department of Defense to effectively address the epidemic of MSIs. The U.S. Military must continue to combine expert researchers synergistically with dedicated leaders so that information gained can be translated into meaningful change.

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