

Musculoskeletal Injuries and United States Army Readiness

Part I: Overview of Injuries and their Strategic Impact

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ABSTRACT

Introduction

Noncombat injuries (“injuries”) greatly impact soldier health and United States (U.S.) Army readiness; they are the leading cause of outpatient medical encounters (more than two million annually) among active component (AC) soldiers. Noncombat musculoskeletal injuries (“MSKIs”) may account for nearly 60% of soldiers’ limited duty days and 65% of soldiers who cannot deploy for medical reasons. Injuries primarily affect readiness through increased limited duty days, decreased deployability rates, and increased medical separation rates. MSKIs are also responsible for exorbitant medical costs to the U.S. government, including service-connected disability compensation. A significant subset of soldiers develops chronic pain or long-term disability after injury; this may increase their risk for chronic disease or secondary health deficits potentially associated with MSKIs. The authors will review trends in U.S. Army MSKI rates, summarize MSKI readiness-related impacts, and highlight the importance of standardizing surveillance approaches, including injury definitions used in injury surveillance.

Materials/Methods

This review summarizes current reports and U.S. Department of Defense internal policy documents. MSKIs are defined as musculoskeletal disorders resulting from mechanical energy transfer, including traumatic and overuse injuries, which may cause pain and/or limit function. This review focuses on various U.S. Army populations, based on setting, sex, and age; the review excludes combat or battle injuries.

Results

More than half of all AC soldiers sustained at least one injury (MSKI or non-MSKI) in 2017. Overuse injuries comprise at least 70% of all injuries among AC soldiers. Female soldiers are at greater risk for MSKI than men. Female soldiers’ aerobic and muscular fitness performances are typically lower than men’s performances, which could account for their higher injury rates. Older soldiers are at greater injury risk than younger soldiers. Soldiers in noncombat arms units tend to have higher incidences of reported MSKIs, more limited duty days, and higher rates of limited duty days for chronic MSKIs than soldiers in combat arms units. MSKIs account for 65% of medically nondeployable AC soldiers. At any time, 4% of AC soldiers cannot deploy because of MSKIs. Once deployed, nonbattle injuries accounted for approximately 30% of all medical evacuations, and were the largest category of soldier evacuations from both recent major combat theaters (Iraq and Afghanistan). More than 85% of service members medically evacuated for MSKIs failed to return to the theater. MSKIs factored into (1) nearly 70% of medical disability discharges across the Army from 2011 through 2016 and (2) more than 90% of disability discharges within enlisted soldiers’ first year of service from 2010 to 2015. MSKI-related, service-connected (SC) disabilities account for 44% of all SC disabilities (more than any other body system) among compensated U.S. Global War on Terrorism veterans.

Conclusions

MSKIs significantly impact soldier health and U.S. Army readiness. MSKIs also figure prominently in medical disability discharges and long-term, service-connected disability costs. MSKI patterns and trends vary between trainees and soldiers in operational units and among military occupations and types of operational units. Coordinated injury surveillance efforts are needed to provide standardized metrics and accurately measure temporal changes in injury rates.

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INTRODUCTION

The United States (U.S.) Army has more than 472,000 active component (AC) soldiers stationed worldwide.¹ Coordinating the health and readiness of this large and diverse force across varied operational environments is challenging. Noncombat musculoskeletal injuries (MSKIs) threaten soldier health and readiness more than any other medical issue.

Military medical readiness refers to the state of soldier or unit health and how that state affects the soldier's or unit's ability to accomplish their mission. Total injuries (MSKIs and non-MSKIs combined) were the leading cause of outpatient medical encounters (2.2 million) among AC soldiers in 2017.² MSKIs accounted for more than eight million limited duty days in 2018,³ 59% of limited duty days for the first 6 months of 2019,⁴ and 65% of medically nondeployable AC soldiers as of March 2019.⁵ In comparison, behavioral health conditions accounted for one million outpatient encounters in 2017² and 10% of limited duty days across the first 6 months of 2019.⁴ Despite the lethality associated with combat-related trauma, MSKIs unrelated to combat (in garrison and deployed settings) are the greatest medical threat to Army readiness.^{6,7}

MSKIs affect readiness through subsequent limited duty days,⁸ decreased deployability rates,^{9,10} and increased medical separation rates.¹¹ MSKIs are also responsible for exorbitant medical costs.^{12–15} A significant subset of soldiers also develops chronic pain or long-term disability after injury; this may increase their risk for chronic disease or secondary health deficits potentially associated with MSKIs.¹⁶

PURPOSE

To review trends in U.S. Army MSKI rates, summarize MSKI readiness-related impacts, and highlight the importance of standardizing surveillance approaches, including injury definitions used in injury surveillance.

METHODS

This review summarizes current reports and U.S. Department of Defense (DoD) internal policy documents. MSKIs are defined as musculoskeletal disorders resulting from mechanical energy transfer,¹⁷ including traumatic and overuse injuries, which may cause pain and/or limit function. This review focuses on various military populations, based primarily on setting (Basic Combat Training [BCT], One Station Unit Training [OSUT], Advanced Individual Training [AIT], and the entire U.S. Army AC [BCT, OSUT, AIT and operational AC units combined]), as well as sex and age. This review excludes combat or battle injuries.

EVOLUTION OF MSKI DEFINITIONS

Medical surveillance of soldiers in the U.S. Army transitioned from paper to electronic medical records in the early 1990s.¹⁸ The medical surveillance system transitioned to the Defense Medical Surveillance System in the late 1990s, based on a U.S. DoD directive.¹⁹ The DoD developed standardized injury

metrics in the early 2000s, based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes.²⁰ These standardized metrics included injury-related musculoskeletal conditions (primarily overuse injuries), given the need to monitor effects of repeated exposures to physiologic and biomechanical stressors during military training. The DoD also developed tools and methods to monitor traumatic injuries and injury-related musculoskeletal conditions.^{21,22}

The U.S. Army Medical Surveillance Activity also developed a more specific metric to track injuries within the Army training population.²³ This metric, known as "training-related injuries," comprises a standardized subset of overuse and traumatic MSKIs of the lower back, pelvis, and lower extremities. Training-related injuries include the most common injuries and musculoskeletal conditions sustained by a relatively young, healthy, military population.²³ These injuries are thought to be associated with the total volume of weight-bearing activity (eg, walking, running, marching) and insufficient time for physiological adaptation or recovery.²⁴

In response to ICD-10-CM implementation in October 2015, the U.S. Army Public Health Center (APHC) revised its metrics to reflect ICD-10-CM diagnostic codes and subsequently developed a comprehensive injury taxonomy to identify and categorize all injury types (including overuse and traumatic MSKI).¹⁷ Overuse injuries (eg, tendinopathies and stress fractures) are defined as typically having a gradual onset resulting from repetitive overload during recurrent physical activity.^{17,25} Traumatic injuries (eg, joint sprains, ligamentous tears, or fractures) are defined as having sudden onset, resulting from high intensity forces sustained at one point in time.¹⁷ APHC's taxonomy is the first classification system to differentiate between MSKI and nonmusculoskeletal injuries, thus enabling further precision with injury reporting and monitoring.¹⁷

Injury surveillance reporting for the entire Army AC has typically included total injury rates (MSKIs and non-MSKIs combined).^{21,26} MSKIs affect muscles, bones, joints, tendons, ligaments, cartilage, and other connective tissues. Non-MSKIs include, but are not limited to, nerve injuries, contusions, blisters, open wounds, and environmental (eg, heat, cold, altitude) injuries.¹⁷

Two recent reports used APHC's injury taxonomy to differentiate between MSKI and non-MSKI when reporting total injury incidence for the entire Army AC¹⁷ and trainees (BCT and OSUT combined).²⁷ Although varied injury definitions can complicate comparisons among reports, the ability to differentiate between MSKI and non-MSKI improves the Army injury surveillance methodology.

READINESS IMPACT OF MSKIs

Sustaining an injury during BCT was associated with greater risk for medical discharge among 2,719 male trainees in 2007.²⁸ Sustaining a time-loss injury during BCT increased risk for discharge among 756 male trainees in 1998.²⁹ Injured

men and women who were advised to halt training and accept assignment to a physical training and rehabilitation program had greater risk for discharge among 1,230 trainees in 1998.²⁹ Low performance on the Army Physical Fitness Test's push-up event independently increased discharge risk for men, while slow two mile run performance independently increased risk for women among the 1,230 trainees.²⁹

Early attrition (within 48 months from initial accession) because of medical issues among first term enlistees across the DoD was approximately 14–15% from 2005–2011.³⁰ MSKIs factored into 91% of all disability discharges within enlisted soldiers' first year of service across 2011 to 2016, accounting for 1,177 discharges.³¹ The relationship between MSKIs and early attrition beyond first year of service is unknown. MSKI-related first-term attrition is critical to readiness, given the limited pool of eligible enlistees. More than 70% of Americans aged 17–24 may be ineligible for military service,³² primarily because of physical health.

MSKIs across the operational AC also impact readiness. MSKIs accounted for 65% of all medically nondeployable AC soldiers as of March 2019.⁵ This is approximately equivalent to 19.1K soldiers or four brigade combat teams.⁵ At any time, 4% of AC soldiers cannot deploy because of MSKIs.⁵

MSKIs further limit military readiness during combat deployments. Nearly 35% of more than 15,000 service members (95% of whom were U.S. Army) reported sustaining at least one nonbattle injury (NBI) while deployed to Iraq or Afghanistan in 2003–2004.³³ Seventy-seven percent of those injured sought medical care.³³ Twenty-one percent required splinting, bracing, or immobilization, while 17% received narcotics.³³ Nearly 18% of all survey respondents reported decreased individual performance because of NBIs.³³

Twenty percent of more than 3,300 service members (77% of whom were U.S. Army) reported at least one NBI (with 85% seeking medical care) while deployed to Iraq, Afghanistan, or the surrounding region from January 2005 through May 2006.³⁴ Thirty-nine percent of those injured reported multiple NBIs.³⁴ Forty-two percent of those injured reported decreased job performance (median time of 6 days); 19% required other service members or a shift change to cover their duties because of their NBIs.³⁴

At least 30% of all medical evacuations from both recent major combat theaters (Iraq and Afghanistan) were for NBIs, including spinal pain.^{35–38} NBIs accounted for the largest category of soldier evacuations from Iraq and Afghanistan.^{36,38} More than 85% of service members medically evacuated for MSKIs (including spinal pain) failed to return to theater; combat injuries and psychiatric conditions were the only conditions associated with lower return to theater rates.³⁷

MSKIs factored into nearly 70% of soldiers' medical disability discharges (affecting more than 80,000 soldiers) across 2011 through 2016.¹¹ In comparison, psychiatric conditions factored into approximately 40% of medical disability discharges across this time.¹¹ Back/spinal conditions, limitation of motion, and arthritis were the three most common

musculoskeletal conditions factoring into soldiers' medical discharges.¹¹ Back/spinal conditions factored into the medical discharges of more than 45,000 soldiers from 2011 through 2016.¹¹

FINANCIAL IMPACT OF MSKIs

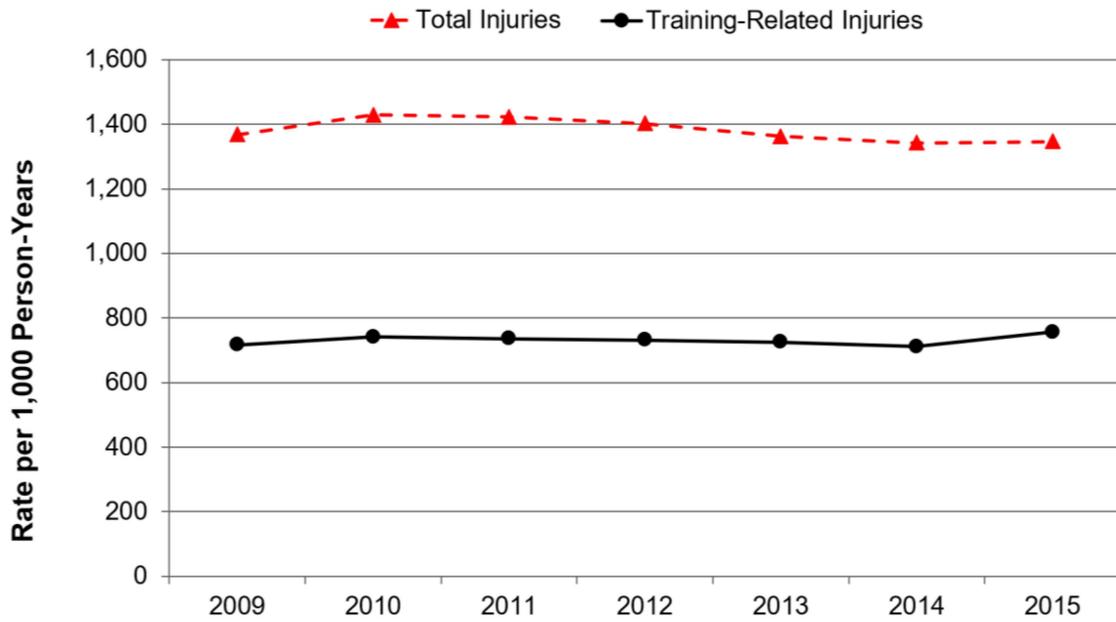
The volume of MSKIs sustained by active duty soldiers has an enormous financial impact. MSKIs among the entire Army AC accounted for \$434 million in direct patient care costs across 2018.¹⁴

The financial cost of the first term attrition because of MSKIs is also considerable. As of 2015, the estimated cost to access and train a recruit was approximately \$75,000 across DoD.³⁰ The actual cost per attrited recruit depends partly on whether one attends BCT and AIT versus OSUT, the length of one's AIT course (technical skills training ranges from several weeks to greater than 1 year across DoD),³⁰ and when one attrits during their first term of enlistment. With musculoskeletal conditions factoring into 1,177 first year discharges (2011–2016),³¹ the first year attrition cost across those 6 years could approach \$88 million (assuming \$75,000 cost for each attrited recruit).

As of 2018, MSK-related, service-connected (SC) disabilities accounted for nearly 37% of all SC disabilities (more than any other body system) among U.S. military veterans receiving compensation.³⁹ Among Global War on Terrorism veterans, MSK-related, SC disabilities account for 44% of all SC disabilities. MSK-related, SC disabilities exceed nine million in number.³⁹ The authors were unable to estimate the annual cost attributable to MSK-related, SC disability compensation because of the U.S. Department of Veterans Affairs' method for calculating composite disability ratings.^{40,41} Estimated annual total payments for SC disabilities exceed \$76 billion.³⁹ **Supplementary Table SI** addresses pertinent musculoskeletal-related medical discharge and service-connected disability reports.

TRENDS IN MSKI RATES (ENTIRE ARMY AC VERSUS TRAINEE POPULATIONS)

Annual total injury rates for the entire Army AC remained relatively stable at 1.3–1.4 new injuries per person-year from 2008 through 2016 (**Fig. 1**).⁸ APHC subsequently reported the total injury rate across 2016 as 1.9 new injuries per person-year after transitioning to injury taxonomy definitions and injury metrics reflecting ICD-10-CM diagnosis codes.⁴² This apparent shift in the total injury rate across 2016 was likely due in part to both the implementation of ICD-10-CM, which introduced over 40,000 new injury diagnosis codes,⁴³ and APHC's revised surveillance methods. The total injury rate for the entire Army AC declined slightly to 1.8 new injuries per person-year (56% of all AC soldiers; 54% of men; 66% of women) in 2017.⁴² Surveillance methods may require further adjustment after better understanding the effects of the ICD-10 transition.



Active Component (AC) injury adjusted to remove deployed injury and deployed person-time.
 Source: U.S. Army Public Health Center, Injury Prevention Program. 2017 Health of the Force Report, Health Outcomes-Injury.
https://phc.amedd.army.mil/Periodical%20Library/2017HealthoftheForceReportWeb_Printer.pdf

FIGURE 1. Annual Injury Rates (Total Injuries and Training-Related Injuries), Entire Army Active Component (AC), 2009–2015⁸.

APHC has routinely conducted injury surveillance targeting Army trainees; the controlled basic training environment enables comparisons of individuals performing similar physical activities and workloads. Total injury visit rates among trainees have traditionally exceeded, but are gradually approaching rates for the entire Army AC (Fig. 2).⁴⁴ Male trainee visit rates were nearly equivalent to rates for all men, whereas female trainee visit rates were approximately 1.7 times greater than rates for all women in 2015 (Fig. 2).⁴⁴

The term trainee refers to (1) enlisted soldiers undergoing 10 weeks of BCT, then technical skills training (AIT) for their respective military occupational specialties or (2) enlisted soldiers undergoing OSUT, which combines BCT and AIT for certain military occupational specialties (infantry, armor, cavalry, field artillery, combat engineer, and military police). OSUT course durations range from 13 to 19 weeks.¹⁷ Soldiers progress to their first operational units after completing BCT and AIT or OSUT.

Varying injury metrics and/or surveillance methods complicate trainee injury rate comparisons across time. Older reports²⁶ indicate that approximately 25% of male and 55% of female Army trainees sustained at least one injury requiring an outpatient medical visit. These injury rates included MSKIs and non-MSKIs. Later reports documented a 46% decline in total injury rates (with a 54% reduction in training-related injuries) from 2003 through 2013 (Fig. 3).⁴⁵

MSKIs accounted for more than 80% of all injuries across the trainee and entire Army AC populations in 2016.^{17,27}

Overuse MSKIs comprise approximately 70% or more of all injuries among trainees and the entire Army AC.^{17,26,27}

Lower extremity injuries (overuse and traumatic combined) comprised 75% of all trainee injuries in 2016 (BCT and OSUT combined).²⁷ Training-related injuries (a standardized subset of MSKIs including lower back and lower extremity injuries) typically account for more than half of all injuries for the entire Army AC (Fig. 1).⁸ Approximately 16% and 40% of male and female trainees, respectively (BCT-only), sustained at least one training-related injury from 2010 through 2012.⁴⁶

Total injury rates exceed training-related injury rates; nearly 40 and 61% of male and female trainees, respectively (BCT-only), sustained at least one injury from 2002 through 2007.⁴⁷ Cumulative total injury incidence was 34% overall, or 30% and 52% for male and female trainees, respectively (BCT and OSUT combined), in 2016.²⁷ Cumulative total injury incidence was 52% for the entire Army AC (50% of men, 61% of women) in 2016.⁸ NOTE: Cumulative total injury incidences are not comparable for trainees and the entire Army AC, because of the different time intervals under study (10 weeks for trainees, 1 year for entire Army AC).

Stress fracture rates among trainees exceed rates for the entire Army AC. Approximately 2% of male and 8% of female trainees (BCT-only) sustained at least one stress fracture from 1997 through 2007.⁴⁸ This would equate to nearly 112 male and 462 female trainees sustaining at least one stress fracture per 1,000 person-years, assuming 9 weeks of BCT from 1997 through 2007.⁴⁸ Nearly 1% of male and

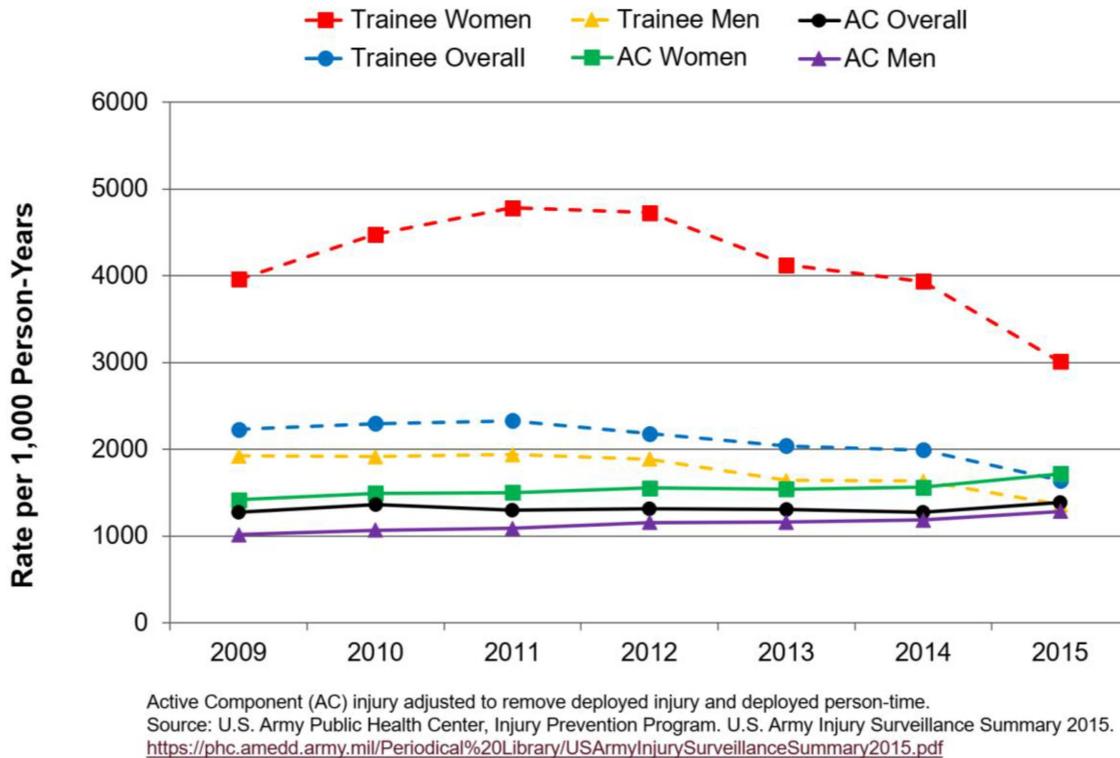


FIGURE 2. Annual Total Injury Visit Rates: Entire Army Active Component (AC) Population and Trainees, 2009–2015⁴⁴.

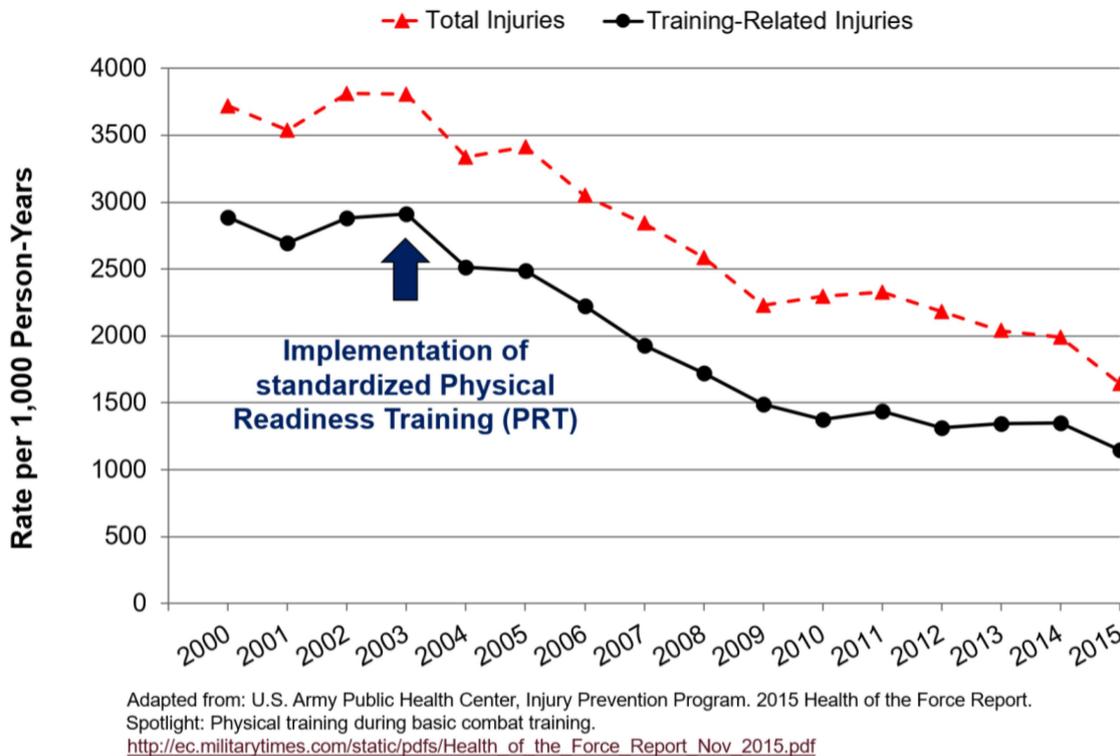


FIGURE 3. Annual Injury Rates (Total Injuries and Training-Related Injuries), U.S. Army Trainees, 2000–2015⁴⁵.

4% of female trainees (BCT-only) sustained at least one stress fracture from 2010 through 2013.⁴⁹ Different injury surveillance methods account in part for the different trainee stress fracture rates in these two reports.^{48,49} In comparison, the unadjusted incidence rate for lower extremity stress fractures across the entire Army AC was 8.43 lower extremity stress fractures per 1,000 person-years from 2009 through 2012.⁵⁰

Supplementary Tables SII and SIII address pertinent trainee and entire Army AC or operational military injury reports.

MSKI PATTERNS

Differences Based on Military Occupation or Operational Unit Type

Soldiers in units previously designated as combat support (eg, aviation, engineer, military intelligence, military police, and communications) and combat service support (eg, logistical, transportation, maintenance, medical, administrative, and finance) had higher incidences of MSKIs when compared with U.S. Army Rangers and soldiers in combat arms units across 1 year.⁵¹ Likewise, soldiers assigned to brigades other than brigade combat teams (eg, sustainment, combat aviation, and field artillery brigades) experience up to 79% more limited duty days⁵² and as much as 93% greater rates of limited duty days for chronic MSKIs than soldiers in brigade combat teams.⁵³ However, reports conflict concerning associations between soldiers' military occupational physical demand levels and risk for injuries, hospitalizations, or disability.^{54–56} Across all U.S. Armed Services, motor transporters sustained higher traumatic injury rates at most anatomic sites than other military occupations from 2008 through 2017.⁵⁷

Deployed soldiers in infantry battalions had similar incidences of low back pain (LBP) as those in noninfantry battalions despite using heavier equipment and body armor, performing more dismounted patrols and more frequently lifting heavy objects.⁵⁸ Potential factors affecting MSKI variances across unit types include differences in soldier physical fitness levels,⁵⁸ ratios of female to male soldiers or older to younger soldiers, differences in duties performed, and ready access to physical therapists within brigade combat teams.⁵⁹

Body Region and Injury Types

The lower back (lumbosacral spine) or the spine in general is frequently reported as the most common injury site across the U.S. Armed Forces, whether deployed or at home station.^{33,58,60,61} The lower back and knee/lower leg accounted for more than 40% of all overuse injuries related to outpatient visits across the entire Army AC in 2015.⁴⁴ Male soldiers had proportionally more overuse injuries of the shoulder; women had proportionally more overuse injuries of the pelvis, hip, and thigh.⁴⁴

Soldiers commonly experience low back, neck, or upper extremity pain during deployment.^{33,58,62} The low back,

hand/fingers, and shoulder were the first, second, and fifth most common sites of NBIs reported by more than 15,000 service members (96% Army) deployed to Iraq or Afghanistan in 2003–2004.³³ The back was the most common site for NBIs requiring medical evacuation from Iraq and Afghanistan from 2001 through 2006; the wrist/hand and shoulder were the third and fifth most common NBI sites requiring evacuation.³⁶

Nearly 80% of male and female soldiers reported experiencing at least one episode of LBP, with 22% reporting moderate or worse symptoms while deployed with a brigade combat team in Afghanistan.⁶³ Wearing, carrying, and lifting heavy loads have been associated with increased injury risk among deployed soldiers.^{58,62–68} Wearing heavier loads may increase risk for neck and shoulder injuries because of compressive forces over the brachial plexus and surrounding structures.⁶⁹

The knee was the most common site for trainee injuries in 2016, accounting for 19.5% of all injuries (overuse: 18.2%; traumatic: 1.3%).²⁷ Lower back and shoulder injuries were less common among trainees, accounting for only 5 and 4% of all injuries, respectively.²⁷

Traumatic injuries comprised nearly 23% of all injuries across the entire Army AC in FY16.¹⁷ Traumatic injury incidence rates were greatest for the foot/ankle, head/neck, and arm/shoulder across the entire Army AC from 2008 through 2017.⁵⁷ Soldiers sustained higher traumatic injury incidence rates at all anatomic sites when compared with the other military branches.⁵⁷

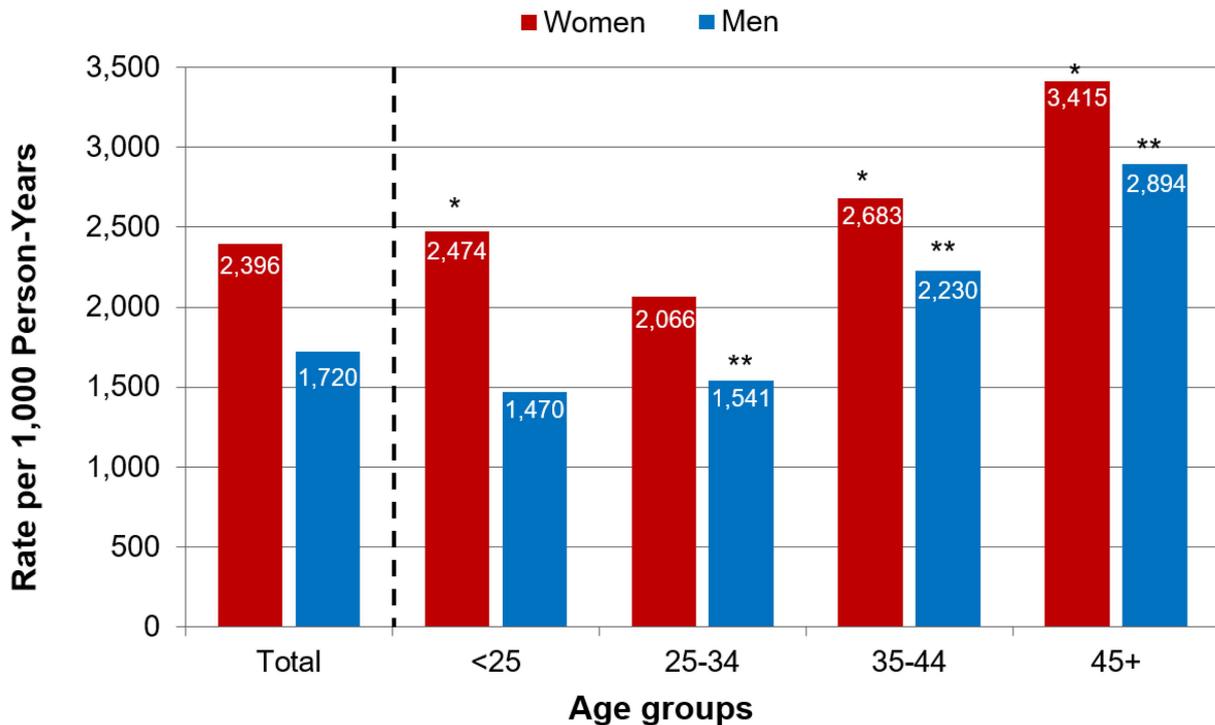
Sex Differences

Entire Army AC women have a 1.3 times greater injury rate (unadjusted for aerobic fitness or other physical characteristics) than men.⁷⁰ Female trainees have a two times greater injury rate than men.⁷⁰

Relatively few reports address sex as an independent risk factor for MSKIs after adjusting for physical fitness and related characteristics. Most show no difference in risk between men and women after accounting for fitness.^{71–76} However, some show women remaining at increased risk (though their risk relative to men decreases),^{46,49} while one report showed women at lesser risk relative to men.⁷⁷

Although sex might not be an independent risk factor after adjusting for physical fitness, women's aerobic fitness, anaerobic power, muscular strength, absolute muscular endurance, and absolute muscular power are typically less when compared with men.^{72,76,78–80} Other factors impacting women's injury risk may include their generally lesser muscle tissue (particularly in the upper extremities)^{81,82} and greater body fat percentages relative to men,^{72,83,84} sex-specific differences in skeletal factors (eg, bone tissue mineralization and geometry) affecting bone strength,⁸⁵ sex-specific hormonal differences (eg, estrogen's effect on tendinous and ligamentous stiffness),⁸⁶ and military equipment ergonomic factors.⁷⁹

Sex differences exist in anatomic distributions of bone stress fractures. Female AC U.S. service members were seven times more likely than men to sustain femoral neck stress



* Statistically significant difference ($p < 0.001$) compared to lowest female rate (age 25-34)

** Statistically significant difference ($p < 0.001$) compared to lowest male rate (age <25)

Active Component (AC) injury adjusted to remove deployed injury and deployed person-time.

Source: U.S. Army Public Health Center. Injury Prevention Program. 2018 Health of the Force Report. Health Metrics-Injury. <https://phc.amedd.army.mil/Periodical%20Library/2018HealthoftheForceReport.pdf>.

FIGURE 4. Total Injury Incidence by Sex and Age (Entire Army Active Component [AC], 2017).⁴²

fractures.⁵⁰ The most common stress fracture sites for female and male trainees in 2016 were the pelvis and lower leg (tibia and fibula), respectively.²⁷

Sex differences also exist in the anatomic distribution of traumatic injuries. Female U.S. service members sustained higher traumatic injury rates for the back/abdomen and lower extremities from the hip distally from 2008 through 2017; male service members sustained higher rates for the arm/shoulder and hand/wrist.⁵⁷ (S. Stahlman, personal communication, 2019).

Age Differences

Older soldiers have a greater injury risk. Total injury rates were higher among soldiers aged 35 or older (entire Army AC) when compared with soldiers younger than 35 in 2017 (Fig. 4).⁴² These relationships hold after controlling for types and volume of physical activity and occupational physical demands.^{6,76}

Increasing age has been associated with higher stress fracture incidence rates among AC U.S. service members.⁵⁰ Those aged 40 or older had higher incidence rates for lower extremity stress fractures overall and at each anatomic location, except the femoral shaft.⁵⁰ Increasing age might increase risk for stress fracture because of decreasing bone mineral density,⁵⁰

lesser osteoblastic activity,⁵⁰ lesser potential for remodeling,⁵⁰ or decreasing fitness with age.⁸⁷

External Causes

Running may account for as much as 50% of soldiers' sports, exercise, or recreational activity-related (SERA) injuries.⁸⁸ Running and foot marching accounted for 30 and 16%, respectively, of injuries sustained by more than 3,000 U.S. male light infantry soldiers across 13 months.⁸⁹ Running was also associated with 32% of injuries sustained by 874 brigade combat team soldiers during 6 months predeployment;⁹⁰ moving/lifting heavy objects and road marching/hiking/walking were the second and third leading causes of injury (13 and 11% respectively).⁹⁰

Running and road marching accounted for 27 and 23% of all injuries, respectively, as reported by 831 soldiers (nearly all male) in two infantry battalions.⁹¹ Thirty-seven percent of soldiers reported at least one injury across the prior 6 months; the back (26%), knee (23%), and ankle (18%) were most commonly injured when road marching. Among these soldiers, road marching presented a higher relative risk of injury than running when accounting for miles of exposure.⁹¹ Marching at least five times per month, carrying loads greater than 25% of body weight, running less than four miles weekly,

and having high occupational lifting demands were associated with increased road marching injury risk.⁹¹ Similarly, road marching presented a nearly five times greater risk per unit of training time than physical training among a large cohort of trainees (seven BCT and OSUT battalions).⁹²

Sports/athletics (22%) and “heavy gear”/lifting (20%) were the most commonly reported causes of “most severe” NBIs among service members (primarily U.S. Army) deployed to Iraq, Afghanistan, or the surrounding region from January 2005 through May 2006.³⁴ Sports/physical training was the leading cause of NBIs requiring medical evacuation from Iraq and Afghanistan (24% and 22%, respectively) from 2001 through 2013;³⁸ lifting/pushing/pulling accounted for 7% and 6% of NBIs requiring evacuation from Iraq and Afghanistan, respectively.³⁸

MSK-Related Comorbidities

A significant subset of soldiers develops chronic pain or disability after injury; they may be at increased risk for secondary health deficits that may be associated with MSKIs. Four percent of soldiers had chronic conditions (requiring limited duty profiling exceeding 90 days across the prior 6 months) that accounted for 51% of all MSK-associated profile days across the entire Army AC in 2016.⁹

Disturbed sleep is often associated with LBP.⁹³ AC service members with pain syndromes are more likely to have insomnia; “poor sleep is a recognized symptom in individuals who have medical disorders associated with pain.”⁹⁴ AC service members requiring mental health medications had poorer outcomes (including lesser potential for return to duty) after hip arthroscopy.⁹⁵

Although reports conflict, female U.S. military veterans are more likely to report persistent postdeployment pain than males.⁹⁶ Persistent pain among veterans has also been associated with (1) post-traumatic stress disorder (PTSD); (2) anxiety, mood and substance use disorders; (3) traumatic brain injury, and (4) body mass index indicative of overweight or obesity.⁹⁶ Lumbosacral spinal conditions, lower extremity disorders, and tendonitis/myalgia are frequently reported among veterans with PTSD.⁹⁷

Individuals with chronic pain or long-term musculoskeletal disability may be at increased risk for certain chronic disease conditions.¹⁶ Back or neck pain or knee/hip/general osteoarthritis (OA) may increase risk for chronic disease (eg, cardiovascular disease, diabetes, cancer, obesity, or chronic respiratory disease).¹⁶ Although unproven, possible causal mechanisms include chronic inflammation, decreased physical activity, weight gain, or disrupted sleep resulting from OA or chronic back/neck pain.¹⁶ **Supplementary Table SIV** addresses pertinent musculoskeletal-related comorbidity reports.

SUMMARY

MSKIs significantly impact soldier health and U.S. Army readiness. MSKIs also figure prominently in medical dis-

ability discharges and long-term, service-connected disability costs. MSKI patterns and trends vary between trainees and soldiers in operational units and among military occupations and types of operational units. Coordinated injury surveillance efforts are needed to provide standardized metrics and accurately measure temporal changes in injury rates.

SUPPLEMENTARY MATERIAL

Supplementary material is available at Military Medicine online.

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