

Characterization of Limited Duty Neuromusculoskeletal Injuries and Return to Duty Times in the U.S. Army During 2017-2018

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ABSTRACT

Introduction:

Neuromusculoskeletal injuries (MSKI) are the leading cause of medical encounters, lost or limited duty days, medical evacuations, and disability in the U.S. Army. In the U.S. Army, objective MSKI incidence rate metrics can be determined through medical encounter data (M2SKIs) with International Classification of Diseases (ICD) 9 and ICD 10 codes or through documented limited duty profiles (LDPs) documenting time-loss MSKI (TLMSKI). The purpose of the current study was to characterize the population incidence of TLMSKIs among U.S. Army soldiers.

Materials and Methods:

This study was approved by the Medical Research and Development Command's Institutional Review Board. This was a retrospective population-level study. The U.S. Army's eProfile system was utilized to characterize all LDPs issued during 2017-2018 and to describe the body regions injured and activities associated with these TLMSKIs.

Results:

The incidence rate of TLMSKIs was found to be 44 and 40 TLMSKI/100 soldier-years for 2017 and 2018, respectively, which is lower than previously published incidence rates using MSKI receiving medical care. Approximately one quarter of the total active duty Army population in 2017 and 2018 recorded limited duty injuries, where those to the ankle/foot region resulted in the most LDPs and those to the knee resulted in the most lost duty days. The majority of all TLMSKIs were associated with fitness training-related activities.

Conclusion:

This descriptive study is the first to present the U.S. Army population rates for MSKIs that result in LDPs, representing key time losses when soldiers cannot participate in their military occupational and physical training tasks. This study utilizes the LDP system to calculate limited duty days instead of attempting to estimate this information from other means. The eProfile system is limited in that it combines body regions such as ankle/foot and does not allow isolation of ankle or foot independently. It is recommended that research and training programs target the identification, development, and validation of effective and scaleable strategies to maximize performance without severely reducing combat effectiveness because of training TLMSKIs.

INTRODUCTION

Neuromusculoskeletal injuries (MSKI) are the leading cause of medical encounters, lost or limited duty days (LDDs), medical evacuations, and disability in the U.S. Army.¹⁻⁵ Once injured, soldiers will be issued a limited duty profile (LDP) if they are unable to fully engage in required occupational and physical training (PT) tasks without worsening the MSKI.⁶ Soldiers on a LDP are not combat ready and therefore LDP injuries significantly reduce the combat effectiveness of the U.S. Army. This reduction in combat effectiveness could be further enhanced as prior injuries are known to be a major risk factor for future MSKI.^{7,8} Research efforts have improved tertiary prevention methods by discovering that early physical therapy intervention reduces LDDs and health care costs.^{9,10} To address primary and secondary prevention, identification

of extent, types, and causes of duty limiting MSKIs will further advise the development of targeted injury prevention and reduction methods. Finally, future research could inform additional tertiary prevention techniques by guiding the allocation of rehabilitation assets to improve combat readiness.

In the U.S. Army, objective MSKI incidence rate metrics can be determined through medical and health care channels utilizing medical encounter data with International Classification of Diseases (ICD) 9 and ICD 10 codes or through documented LDPs. The MSKIs that cause the soldier to seek medical care and result in a medical encounter (M2SKIs) are coded by ICD 9 and ICD 10 diagnoses codes within the electronic health record. Time-loss MSKIs (TLMSKI) are those severe enough to cause a medical provider to issue a duty restriction, LDP, and are captured in the eProfile system. The electronic health record does not link to the eProfile system to verify the disposition. To date, little to no research has been performed examining TLMSKIs in the U.S. Army. The incidence of TLMSKIs is predicted to be high, but most previous studies providing estimates have utilized self-report surveys and therefore may be subject to recall bias or other factors

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doi:10.1093/milmed/usaa392

Published by Oxford University Press on behalf of the Association of Military Surgeons of the United States 2021. This work is written by (a) US Government employee(s) and is in the public domain in the US.

influencing reporting (e.g., response bias).^{11,12} Surveys have reported between 10% and 36% of service members and were issued a LDP while deployed.¹³⁻¹⁶ In a recent report, 16% of medical encounters coded with M ICD-10 codes (diseases of the musculoskeletal system and connective tissue) had a disposition of limited duty selected by the medical provider in the coding section of the encounter, while the rate was 13% among those injuries coded with S or T ICD 10 codes (injury, poisoning, and certain other consequences of external causes).⁵ These rates may be an underrepresentation of the number of LDPs actually issued as providers may skip this section for expediency.

Musculoskeletal injuries are the leading cause for LDDs and account for more LDDs compared to illnesses, according to survey and record review studies.¹⁷⁻¹⁹ The average number of LDDs per MKSI varies; record reviews found an average number of LDDs of 16-35 days while in garrison and 6-18 days while deployed.^{13,14,19,20} In another study, LDDs were estimated based on the amount of recovery time three medical providers stated would be required to return to combat readiness for specific ICD 9 diagnoses and the median time was chosen, thus providing a gross estimation of LDDs.²¹ The current article will examine the LDDs for the U.S. Army using LDDs documentation from the eProfile system rather than estimates based on self-report surveys or record reviews.

There has been no population-level examination of those body regions receiving the most MSKIs resulting in LDPs and LDDs. As with data on LDDs, summaries of the most commonly injured body regions largely result from survey studies or reviews of the electronic medical records among specific military groups. Low back region has been reported to be the most commonly injured body region during self-report survey studies and record reviews during deployment.^{16,22,23} One survey study found that the most commonly injured body regions were the lumbar spine (24%), hand/fingers (23%), ankle/foot (22%), knee (18%), and shoulders (12%).¹⁶ In 2018, according to electronic medical records of M2MSKIs, the most commonly injured body regions in U.S. Army active duty (AD) soldiers while in garrison were pain in joint (53%), low back pain (24%), pain in limb (10%), and neck pain (6%).⁵ There are very few research studies looking at LDPs and LDDs by body region injured, but those that do usually find that the lower extremity MSKIs result in the most LDDs.^{25,26}

Similarly, through surveys and record reviews, limited research has been performed examining activities associated with MSKI in the U.S. Army. Common activities associated with MSKI in garrison include lifting or wearing gear, running, PT, and sports.^{20,27,28} Among a group of U.S. Army mechanics, PT, mechanical work, airborne activity, and ruck marching were the leading causes of injury in women while PT, mechanical work, sports, and airborne activity were the leading causes in men.²⁰ In deployed studies, lifting objects and wearing body armor and equipment have consistently been shown to be a major contributor to MSKIs.^{13,16,27-29}

The purpose of the current study was to characterize the population incidence of TLMSKIs among U.S. Army soldiers as determined from eProfile during 2017-2018 and to describe the body regions injured and activities associated with these TLMSKIs to assist with future injury prevention efforts.

METHODS

Population

This study utilized data from the U.S. Army eProfile System, accessed through the Soldier Performance, Health, and Readiness (SPHERE) database at the U.S. Army Research Institute of Environmental Medicine. The SPHERE is a comprehensive data repository that includes administrative data, medical encounter information, and performance metrics (e.g., Army fitness tests) for all U.S. Army personnel including AD, National Guard (NG), and Army Reserve (AR) ($n > 7$ million). The SPHERE operating procedures are reviewed and approved by the Medical Research and Development Command Institutional Review Board.

LDP and LDD Definition

This study identified all AD, NG, and AR soldiers who received an incident temporary TLMKSI during calendar year 2017 and calendar year 2018, identified using the current LDP form instituted in 2016. There is not a definition manual for the eProfile system. For these analyses, specifically, the definition of TLMSKIs of interest were those recorded within the following categories: musculoskeletal, podiatry, neurology, or neurosurgery. Podiatry, neurology, and neurosurgery were included with musculoskeletal as these additional three categories include injuries to the neuromusculoskeletal systems such as Achilles tendonitis, radiculitis, and burst fractures. To ensure profiles included in the analyses were new incident profiles when counted for the 2017 and 2018 periods, a 6-month look-back window (June 2016 to December 2016 for 2017 and June 2017 to December 2017 for 2018) was utilized.

The eProfile system combines several body regions and reports the following regions: concussion, cervical/thoracic spine, shoulder, upper arm, elbow/wrist/hand, lumbar spine, sacrum/coccyx, hip, femur/thigh, knee, lower leg, ankle/foot, and unknown. Unique LDPs were identified by body region categories present in the eProfile system and laterality (left, right, unspecified, and bilateral). Any LDPs recorded within 60 days of each other for the same body region and laterality were considered to be part of the same TLMSKI and the total profile times were added together for analyses of the total LDDs per TLMSKI. Sixty days was chosen as this is the longest reasonable amount of time a soldier may not have to perform fitness or occupational tasks and hence not be required to show an active LDP, 2 weeks of out-processing an old unit, 30 days of vacation, and 2 weeks of in-processing a new unit (60 days). Any LDPs recorded for the same body region and laterality outside of 60 days were considered new TLMSKIs, with the exception of concussion injury profiles,

which were all considered as the same injury with multiple reinjury because of the unique etiology of concussions. Any LDPs listed as bilateral were classified as two TLMSKIs, one right, and one left.

Within the eProfile system, providers may choose from a finite list of activities associated with the injury, using a pull-down menu. For comparison, two summary categories of the activities were created: sports/fitness activities and occupational or work-related activities.^{15,20}

Statistical Analysis

Descriptive statistics were generated to describe total soldiers with TLMSKIs, total LDPs, and total LDDs across all three components of the U.S. Army. As many NG and AR soldiers are treated by medical providers without access to eProfile, the ability of eProfile to be inclusive of all TLMSKIs in NG and AR is severely limited and the remainder of analyses were conducted among the AD only. Rates were further broken down by body region and activity associated with injury. When calculating the LDDs per soldier, concurrent LDDs were counted once instead of summed as soldiers may have multiple LDPs occurring concurrently. When calculating total LDDs per activity or body region, all days were counted regardless of concurrent LDPs. The incident TLMSKI rate was calculated using the total number of incident TLMSKIs divided by the 100 soldier-years for 2017 and 2018, respectively. Soldier-years were calculated by adding all available soldier-months for the AD soldiers during the time periods and converting to years. Statistical analysis was performed with SAS Software (version 9.4, SAS Institute Inc, Cary, NC, USA).

RESULTS

The total Army AD population during 2017-2018 was 530,571 and 529,998, respectively. During both years, the

average age was 28 years with an average of 7 years in service and 15% of the population was female. Officers made up 15% of the population. The population with TLMSKIs during 2017-2018 also had an average age of 28 years with 7 years in service and was 19% female (risk ratio (RR): 1.26 (1.24-1.27 compared to male soldiers) and 9%-10% officer (risk ratio: 0.68 (0.67-0.70 compared to enlisted soldiers)). The incidence rate of TLMSKIs was found to be 44 and 40 TLMSKI/100 soldier-years for 2017 and 2018, respectively (Table I). Counts, rates, and number of LDDs for 2018 were lower than 2017 across all components (Table I).

The TLMSKIs to the ankle/foot region accounted for the most LDPs in both 2017 and 2018 followed by the knee, lumbar spine, shoulder, and hip (Table II). The distribution by body region is similar between 2017 and 2018, while the total and mean LDDs is lower in 2018 compared to 2017.

The most common activities associated with TLMSKIs accounting for the most LDDs in the AD Army were running followed by falls/slips/trips, PT (not running or strength training), ruck marching, and other work tasks (Table III). The LDDs for all work-related activities combined together were 1,586,723 LDDs in 2017 and 1,109,610 LDDs in 2018, whereas for fitness training-related and sport-related activities, the LDDs were approximately three times greater at 4,330,352 LDDs in 2017 and 3,247,467 LDDs in 2018. The total and mean LDDs were less in 2018 compared to 2017.

While TLMSKIs in the ankle/foot regions resulted in the most LDPs, those to the knee resulted in a slightly higher number of LDDs, compared to the other body regions. The leading activity associated with knee TLMSKIs was running followed by fall/slip/trip and ruck marching/load carriage (Table IV). There were more LDDs and TLMSKIs from total fitness training/sports in 2017 than 2018 and more work-related LDDs and TLMSKIs in 2018 compared to 2017.

TABLE I. General Limited Duty Day Description for TLMSKIs by Calendar Year for U.S. Army Components

Metric	Calendar year 2017			Calendar year 2018		
	Active	Guard	Reserve	Active	Guard	Reserve
Total number of soldiers	5,30,571	3,76,411	2,24,173	5,29,998	3,73,234	2,15,278
Total number of soldiers with limited duty profile (LDP)	1,36,007	29,906	15,550	1,22,103	25,204	13,370
% Soldiers with LDP	26%	8%	7%	23%	7%	6%
Total incident injuries	2,07,946	40,712	22,732	1,86,645	34,395	19,436
Incident injury rate (100 soldier-years)	44.9	11.9	11.5	40.2	10.3	10.1
Total number of limited duty days (LDDs) per injured soldier ^a	10,222,742	2,833,882	1,439,175	7,482,249	1,956,355	1,087,090
Average LDDs per injured soldier (SD)	75.2 (76.2)	94.8 (83.2)	92.5 (77.8)	61.3 (56.7)	77.6 (62.2)	81.3 (60.6)
Median LDDs per injured soldier (IQR)	46 (22-98)	83 (31-119)	89 (31-92)	41 (21-89)	63 (31-91)	80.5 (31-91)
Average LDDs per all soldiers in component (SD)	19.3 (50.6)	7.5 (34.7)	6.4 (31.2)	14.1 (37.5)	5.2 (25.3)	5.0 (24.8)
Total number of LDDs for TLMSKIs ^a	12,360,950	3,489,196	1,894,246	9,030,374	2,377,053	1,419,889
Average LDDs per TLMSKI (SD)	58.7 (63.6)	84.0 (76.0)	82.4 (68.9)	47.8 (45.9)	68.5 (55.7)	72.5 (53.1)
Median LDDs per TLMSKI (IQR)	31 (15-81)	66 (30-91)	83 (31-91)	31 (15-62)	60 (29-91)	65 (31-91)

^aThe values for LDDs per soldier are smaller than total number of LDDs per injury because soldiers may have multiple concurrent TLMSKIs but each day is only counted once regardless of number of profiles for this value. However, in computing the LDDs per TLMSKI for a soldier with a profile with two injuries on the same day, these would be counted as 2 days in this instance to get the total number of LDDs even if concurrent.

Abbreviations: LDD—limited duty days, TLMSKI—time loss neuromusculoskeletal injury.

TABLE II. Body Region Resulting in TLMSKIs, (Ranked by LDDs) by Calendar Year for the Active Duty U.S. Army

Body region	Calendar year 2017				Calendar year 2018			
	Total TLM-SKIs	Percent	Total LDDs	Mean LDDs (SD)	Total TLM-SKIs	Percent	Total LDDs	Mean LDDs (SD)
Knee	41,815	20%	2,534,176	60.6 (65.5)	37,563	20%	1,831,262	48.8 (46.3)
Ankle/foot	42,829	21%	2,377,029	55.5 (62.0)	37,961	20%	1,719,544	45.3 (44.9)
Lumbar Spine	28,695	14%	1,77,278	60.9 (64.6)	25,295	14%	1,195,686	47.3 (45.2)
Shoulder	19,089	9%	1,399,582	73.3 (74.6)	17,087	9%	1,001,434	58.6 (53.7)
Hip	18,377	9%	1,109,955	60.4 (67.0)	17,228	9%	8,45,819	49.1 (47.1)
Elbow/wrist/hand	17,148	8%	9,66,179	56.3 (56.5)	15,375	8%	7,44,812	48.4 (43.9)
Lower leg	17,685	9%	8,91,000	50.4 (51.8)	16,246	9%	7,12,199	43.8 (39.5)
Cervical/thoracic spine	7,643	4%	4,11,470	53.8 (60.7)	6,300	3%	2,78,273	44.2 (44.5)
Unknown ^a	3,117	2%	1,28,434	41.2	5,686	3%	3,02,705	53.2
Concussion	2,857	1%	1,13,241	39.6 (53.9)	2,992	2%	97,528	32.6 (37.8)
Femur/thigh	2,862	1%	1,08,731	38.0 (42.5)	2,927	2%	94,375	32.2 (32.2)
Sacrum/ coccyx	1,209	1%	54,402	45.0 (47.7)	987	1%	36,254	36.7 (35.4)
Upper arm	804	0%	39,681	49.4 (52.2)	690	0%	28,708	41.6 (39.2)

^aOne thousand seven hundred and eighty-nine injuries were missing body region in 2017 and 1,482 in 2018 and thus coded as unknown. Abbreviations: LDD—limited duty days, TLMSKI—time loss neuromusculoskeletal injury.

TABLE III. Activities Associated with TLMSKIs by Calendar Year (Ranked from Highest to Lowest LDDs from 2017)

Activity associated with TLMSKI	Calendar year 2017				Calendar year 2018			
	Total TLM-SKIs	%	Total LDDs	Mean LDD	Total TLM-SKIs	%	Total LDDs	Mean LDD
Not applicable/other	72,231	35%	5,314,857	73.6	64,888	35%	3,815,477	58.8
Running ^b	60,386	29%	3,025,974	50.1	56,787	30%	2,345,622	41.3
Fall/slip/trip	10,895	5%	5,46,866	50.2	10,034	5%	4,30,593	42.9
PT (not running or strength training) ^b	9,579	5%	4,96,948	51.9	7,593	4%	3,26,522	43
Work tasks (others) ^a	7,524	4%	4,77,604	63.5	5,228	3%	2,57,147	49.2
Ruck marching/load carriage ^a	8,527	4%	4,11,484	48.3	8,402	5%	3,43,532	40.9
Team sports ^b	7,215	3%	3,41,457	47.3	5,980	3%	2,42,740	40.6
Strength training ^b	7,313	4%	3,16,362	43.3	6,351	3%	2,36,767	37.3
Work tasks (lifting) ^a	5,602	3%	2,87,278	51.3	5,032	3%	2,04,102	40.6
Motor vehicle/ motorcycle accident	4,922	2%	2,64,197	53.7	4,589	2%	2,00,813	43.8
Fast rope/parachute ^a	3,057	1%	1,96,192	64.2	3,120	2%	1,57,507	50.5
Individual sports ^b	2,706	1%	1,49,611	55.3	2,143	1%	95,816	44.7
Off-duty activities (nonvehicular)	2,789	1%	1,12,709	40.4	2,144	1%	75,735	35.3
Combatives/martial arts ^a	2,278	1%	1,05,530	46.3	1,897	1%	75,549	39.8
Work tasks (mechanical/repair work) ^a	1,491	1%	65,175	43.7	1,356	1%	48,596	35.8
Battle injury	534	0%	49,297	92.3	388	0%	29,511	76.1
Work tasks (pushing or pulling) ^a	743	0%	43,460	58.5	526	0%	23,177	44.1
Environmental, cold	106	0%	3,146	29.7	164	0%	4,210	25.7
Environmental, heat	42	0%	1,873	44.6	23	0%	908	39.5
Summary								
Total fitness training/sports ^b	87,199	42%	4,330,352	49.7	78,854	42%	3,247,467	41.2
Total work-related ^a	29,222	14%	1,586,723	54.3	25,561	14%	1,109,610	43.4

% Percent

^aWork-related activity.

^bFitness training-related or sports-related activity.

Abbreviations: LDD—limited duty days, PT—physical training

DISCUSSION

This descriptive study is the first to present the U.S. Army population rates for MSKIs that result in LDPs, representing key time losses when soldiers cannot participate in their military occupational and PT tasks. The incidence rate of TLMSKIs

in the AD U.S. Army was found to be 40-45 TLMSKI/100 soldier-years with 23%-26% of AD soldiers with a TLMSKI. The shoulder followed by the hip, knee, and low back resulted in the longest return to duty times. These TLMSKIs impose a great burden on the U.S. Army in terms of maintaining combat

TABLE IV. Activities Associated with Knee TLMSKI by Calendar Year (Ranked by Total TLMSKI in 2017)

Activity associated with injury	Calendar year 2017			Calendar year 2018		
	Total TLMSKI	Total LDDs	Mean LDD	Total TLMSKI	Total LDDs	Mean LDD
Running^b	19,235	9,91,830	51.6	17,893	7,49,924	41.9
Team sports^b	2,016	1,21,260	60.1	1,361	71,679	52.7
Not applicable/other	1,698	97,047	57.2	10,616	6,66,184	62.8
Fall/slip/trip	1,749	85,744	49.0	1,665	70,808	42.5
Ruck marching/load carriage^a	1,652	78,542	47.5	1,635	63,382	38.8
PT (not running or strength training)^b	1,519	88,129	58.0	1,292	59,519	46.1
Work tasks (others)^a	48	2,391	49.8	769	41,465	53.9
Individual sports^b	497	33,131	66.7	395	19,801	50.1
Strength training^b	475	22,054	46.4	387	15,363	39.7
Fast rope/parachute^a	453	30,409	67.1	470	23,688	50.4
Motor vehicle/motorcycle accident	442	23,630	53.5	448	21,502	48.0
Combatives/martial arts^a	264	14,694	55.7	175	8,806	50.3
Off-duty activities (non-vehicular)	258	12,085	46.8	161	6,268	38.9
Work tasks (lifting)^a	174	8,555	49.2	162	7,202	44.5
Work tasks (mechanical/repair work)^a	103	4,403	42.7	76	2,294	30.2
Work tasks (pushing or pulling)^a	45	2,314	51.4	27	1,373	50.9
Battle injury	44	4,161	94.6	28	1,933	69.0
Environmental, cold	3	77	25.7	3	71	23.7
Summary						
Total fitness training/sports^b	23,742	1,256,404	52.9	21,328	9,16,286	43.0
Total work-related^a	2,739	1,41,308	51.6	3,314	1,48,210	44.7

^aWork-related activity.

^bFitness training-related or sports-related activity.

Abbreviations: LDD—limited duty days, PT, physical training, TLMSKI—time loss neuromusculoskeletal injury.

readiness. The only other published study examining U.S. Army profile rates from eProfile was conducted by Teyhen and colleagues in 2011-2012, before the eProfile system was in widespread use.³⁰ This earlier study of 1,500 soldiers using select U.S. Army units utilized hand counts from paper copies of profiles and they observed a lower incidence rate of 36 TLMSKI per 100 soldier-years. These researchers recruited participants from one base and restricted participants to under 45 years of age and soldiers with no injuries at the start of the study.³⁰

Currently, all LDPs must be entered into eProfile and therefore it is assumed that the current study (compared to earlier ones examining paper copies) resulted in a more complete compilation of LDPs. The earlier study by Teyhen and group excluded already injured soldiers, and as a result excluded any new injuries these soldiers developed, additionally contributing to the reasons the current study may have found a higher rate of TLMSKI.³⁰ Furthermore, the current study investigated the entire AD U.S. Army instead of limited selection of available units resulting in a more diverse spread of unit type which could have also resulted in the higher rate of TLMSKI as different types of units tend to have different injury rates.^{20,31,32}

As anticipated, studies of M2SKI rates result in rates almost three times TLMSKI rates. In three studies using medical record reviews to investigate MSKI in infantry soldiers, 55%-63% had a M2SKI and incident rates ranged from 95 to 156 M2SKI per 100 soldier-years.^{19,33,34} A more

recent study looking at an infantry brigade combat team in 2010-2011 found an incidence rate of 53 M2SKI per 100 soldier-years.²⁶ The current study is describing injuries that affect a soldier's ability to perform his/her occupation (including training). As in sports, a soldier is not "healed" until he/she can return completely to his/her occupation.³⁵ Therefore, we posit that MSKIs requiring LDDs (or TLMSKIs) impose a greater burden on the U.S. Army than those that only result in seeking medical care and recommend future studies and prevention efforts focused on reducing MSKIs that decrease soldier readiness as these are more directly relevant to military occupational effectiveness.

Although not the primary focus of this study, it is important to note that incidence of MSKI when soldiers are deployed differs from when they are stationed in garrison. While deployed, 16%-35% of soldiers self-reported an incident MSKI, but these MSKI were not limited to only MSKI resulting in LDDs.^{13,16,36} In garrison, the number of M2SKI is higher than TLMSKI, 53-156 per 100 soldier-years compared to 36-45 per 100 soldier-years regardless of TLMSKI collection method.^{19,26,30,33,34} The results of the current study, 26% of soldiers with an injury severe enough to negatively impact their occupation or training resulting in a LDP, fit better into the range of soldiers reported with MSKI in deployed environments, even though the physical requirements while deployed are more demanding compared to in garrison. Deployed soldiers may only self-report an MSKI if the MSKI is severe enough to cause a limitation in their occupational tasks or

training. This may explain why the results were more similar to the current study with same levels of MSKI severity being compared, e.g., they likely are all severe enough to negatively impact occupational or training tasks.

In the current study, the average LDDs per incident TLM-SKI was 59 (2017) and 48 (2018) days and the average LDDs per soldier was 75 and 61 days (the higher LDDs per soldier being related to soldiers often having multiple injuries). The average LDDs per soldier for TLMSKI based on examination of eProfile data in a recent study of AD soldiers was 36 LDDs.³⁰ A number of other studies have examined LDDs, but have relied on surveys or medical record reviews. A study based on self-report averaged LDDs by type of TLMSKI instead of all combined, but the range of these was from 6 to 60 LDDs, with only two TLMSKI injury categories over 50 LDDs (i.e., fractures and nerve injuries).²⁶ A study examining infantry, engineers, artillerymen, and special forces found that the average LDDs per soldier varied from 6 (engineers) to 37 (special forces) days, which is still much lower than that in the current study.³⁷ The average LDDs for any time loss injury in mechanics was 35 days/incident TLMSKI in a 2007 study.²⁰ Two separate 12-month record reviews studies at Fort Drum found the average LDDs per any TLMSKI were 6 and 15 days (studies from 2002 and 2009).^{25,37} In light infantry battalions, there were 16 LDDs per TLMSKI.¹⁹ In summary, the average LDDs reported in all previous publications were lower than those findings of the current study. Challenges in identifying the total lengths of time on LPD for every soldier from reviewing medical records and opportunities for recall bias on survey responses most likely contributed to this difference. In the current study, we linked together all profiles for one TLMSKI to get a total number of LDDs across multiple profiles, which might account for some of the differences if multiple LDPs were written for one TLMSKI across time and other studies did not combine these days together.

In the current study, the most commonly injured body regions were ankle/foot, knee, low back, and shoulder. In the most recent study using a sample similar to our population, a similar distribution of M2SKI by body regions was observed even though that study was not restricted to looking at TLMSKI only.³⁰ Engineers and artillerymen had a similar distribution of MSKI by body region to the current study: ankle/foot, knee, low back, and upper extremity.³⁷ The lower extremity has been identified as the most commonly injured body region in numerous studies.^{20,21,26,37} Additionally, the lower extremity, specifically the knee, followed closely by the foot/ankle, resulted in the greatest reduction in combat readiness (highest total LDDs, over 1,710,000 days/year each). However, the individual injured body regions with the highest average LDDs per injury (most severe) were shoulder (73(2017)/59(2018) LDDs), knee (61/49 LDDs), lumbar spine (61/47 LDDs), and hip (60/49 LDDs). Survey results of a study in an infantry brigade combat team found similar results in that the lower extremity MSKI resulted in the highest total LDDs followed by a category combining the

upper back, shoulder, and lower back.²⁶ The TLMSKIs to the arm/elbow/wrist/hand resulted in the most LDDs per MSKI followed by the upper back/shoulder/lower back.²⁶ These results are somewhat in line with the current study, but by combining so many separate body regions, it becomes difficult to truly compare the results. A less recent study using engineers and artillerymen found among engineers, injuries to knee accounted for the highest total LDDs, but among artillerymen, the highest total was for low back injuries.²⁵ The TLM2SKIs to the knee in both types of soldier resulted in the most LDDs per M2SKI.²⁵ These findings, although based on medical records, are comparable to those in the current study where the knee accounted for the most total LDDs in the Army and had the second highest LDDs per TLMSKI.

Similar to this study, a prospective study of an infantry battalion over a year's time also found based on medical records that the shoulder injuries were responsible for the most LDDs per M2SKI.¹⁹ These results indicate that it may be best to compile TLMSKIs to the shoulder in a category by itself to obtain an accurate measure of their effect on combat readiness as opposed to combining them with other body regions. Overall, the results of the current study support previous research indicating that the U.S. Army needs to better target injury prevention efforts on the lower extremity and low back and additionally points to shoulder injuries as important prevention targets to best reduce combat readiness based on LDDs.

The most common specific activity listed by providers as associated with the TLMSKIs in 2018 in the current study was running followed by falls/slips/trips, PT, calisthenics, and ruck marching/load carriage. These findings are similar in 2017 except activities involving work tasks (other) resulted in more LDDs than ruck marching. Running is often reported as the activity most associated with MSKIs and LDDs in the Army.^{19,26,38} Often studies, however, do not or are not able to separate running from PT when they assess activities associated with injuries. In these cases, PT is often the activity most associated with MSKI.^{15,20} Many research studies have identified PT as either the primary cause of MSKI or one of the top three.^{19,37-40} In the current study, when combined, TLMSKIs occurring during fitness training or sports activities account for 2.73 and 2.93 times more LDDs than during work-related activities. In response to the large numbers of MSKI from fitness training, the U.S. Army reduced the recommended amount of running mileage and increased functional fitness training in 2010 with the implementation of physical readiness training.⁴¹ This prevention program led to 10%-24% less injuries while maintaining the soldier's running speed and saved \$4.5 million in health care costs as noted by several research studies.⁴²⁻⁴⁵ One method of reducing running mileage is to substitute some ruck marches instead of distance runs.⁴⁶ However, in 2017 and 2018, the Army still has >2.7 times as many MSKIs from fitness training or sports compared to work tasks, which points to the continued need to identify methods of fitness training that limit or reduce

LDDs. According to the current study, running accounts for over seven times the number of injuries, 11 times the number of LDDs, and slightly more LDDs per TLMSKI than ruck marching. This observation suggests that the U.S. Army needs to address strategies that target further reductions in running MSKIs. However, even though ruck marching results in less combat non-readiness than running according to the current study, it is noteworthy that the risk of MSKI per mile is higher for ruck marching than running. Therefore, planned interventions to target reduction of running injuries should use caution if these simply involve removing running training days and replacing them with ruck marching.⁴⁷ Other substitute activities or on/off scheduling that will not further increase MSKI should be evaluated.

The current study further examined the activities associated with TLMSKIs to the knee, as those injuries resulted in the most LDDs. In other studies of military populations, the knee often accounts for the largest proportion of these injuries (ranging between 18% and 26%), but none of the studies examined the activities associated with these knee MSKIs.^{19,20,30,48,49} The current study found that running, falls/slips/trips, and ruck marching/load carriage are responsible for a large proportion of the knee TLMSKIs. This is to be expected as these are often cited as the cause of lower extremity MSKIs in general.^{19,26,38,47,50}

The current study investigated TLMSKIs and LDPs in AD, NG, and AR soldiers. Active duty soldiers perform soldier tasks as their everyday jobs and therefore have a greater need for a LDPs than most serving in the NG or AR. Limited duty profiles are designed to protect a soldier from participating in work or training tasks that could worsen or prolong his/her condition. In the NG and AR, soldiers usually do not work as soldiers during the week and may only do it one weekend a month or during short time periods, as such, this may be the reason that the number of LDPs and LDDs were lower in the NG and AR. Relatedly, they are exposed to less soldier training and occupational tasks, and thus the number of MSKIs from their time as soldiers would likely be less, while the number of MSKIs from their everyday civilian occupations might be more. Interestingly, while the number of MSKIs in the current study was much lower in the NG and AR, the average LDDs for the NG and AR were much higher, so even though NG and AR had fewer MSKIs than the AD, the TLMSKIs that do receive LDPs appear to be more severe compared to the AD. This may be due to a number of undetermined factors. The NG and AR may only be requesting LDPs for more severe MSKIs due to the greater administrative difficulty in requesting a LDP in the NG and AR compared to AD, the NG and AR may only be engaging in military tasks and training less frequently which may lead to more severe MSKI, or a number of other possible factors. More research is needed to discover the reason for the difference in average LDDs between the NG and AR and AD.

There are several limitations to the current study. National Guard and AR soldiers most likely also use their civilian

insurance and medical providers to treat MSKI as these resources are more easily accessible than military insurance or military treatment facilities and address all MSKIs not just those occurring during their military duty. Civilian medical clinics do not have access to eProfile and would either not write a LDPs or write one on paper. All of these factors indicate that using eProfile to assess TLMSKIs in the NG and AR will miss a number of these injuries; these populations may be better served by conducting widespread surveys. The TLMSKIs reflect a specific aspect of military readiness but do not portray the overall health care burden of injuries in the U.S. Army. The burden of injuries on the military health care system is likely much greater and future research including M2MSKI would also inform additional tertiary prevention techniques by guiding the allocation of rehabilitation assets to improve combat readiness. Additionally, future research is needed to investigate risk and protective factors for TLMSKI including factors such as sex and occupation.

CONCLUSION

Time loss musculoskeletal injuries represent a serious deleterious effect on the soldier readiness of the U.S. Army as they indicate the period when soldiers are not able to perform their physical or occupational training regimens. Approximately one quarter of the total AD Army population in 2017 and 2018 recorded limited duty injuries, where those to the ankle/foot region resulted in the most LDPs and those to the knee resulted in the most LDDs. The majority of all TLMSKIs were associated with fitness training-related activities. It is recommended that research and training programs target the identification, development, and validation of effective and scalable strategies to maximize performance without severely reducing soldier readiness due to training TLMSKIs.

ACKNOWLEDGMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST STATEMENT

None.

DISCLAIMER

The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Army or the Department of Defense.

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Limited Duty Neuromusculoskeletal Injuries

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