

FOOT MARCHING, LOAD CARRIAGE, AND INJURY RISK

TECHNICAL INFORMATION PAPER No. 12-054-0616

PURPOSE.

This document provides information regarding injuries associated with Army foot marching and load-carriage activities.

REFERENCES.

See Appendix A for complete reference information.

POINTS OF MAJOR INTEREST AND FACTS.

Background.

This paper describes injuries associated with foot marching and operational military tasks such as patrolling that require Soldiers to carry heavy loads of equipment and supplies. These are often referred to as “load-carriage” injuries in scientific literature.¹ Terms used by the Army to describe activities associated with load-carriage injuries include “ruck marches,” “forced marches,” “loaded marches,” and “road marches.” Other operational and training-related lifting activities may also be included. During these activities, Soldiers often carry the heaviest loads on their backs in backpacks or rucksacks. Adding to the Soldiers’ loads are other items such as body armor and protective clothing, ammunition, and other supplies on various parts of their body.²⁻⁸ Appendix B provides a visual example of the equipment and associated weights.

In recent operations, Soldiers have carried loads weighing over 100 pounds.^{1, 8, 9} These weights often exceed guidelines for optimal military performance thresholds for combat operations (20% to 30% body weight) and sustained non-contact operations (45% body weight).³ Heavy loads carried or worn on the body have been shown to increase the energy cost of locomotion, lead to more rapid fatigue, alter the mechanics of walking, and place stresses on the musculoskeletal system.^{1, 3, 6, 7, 10-17} These factors can increase Soldiers’ risk of developing a variety of injuries.^{1-6, 11, 13 14, 18} Military leaders, medical providers, and Soldiers have expressed interest in learning about preventing foot marching and load-carriage related injuries.^{8, 19, 20}

Risk Assessment.

Exposures. Military mission success can depend on the efficiency with which personnel carry required equipment over long distances and varying terrains while maintaining combat performance capabilities. To optimize these capabilities, foot marching with carried loads remains a core element of military training.¹⁻⁴ Soldiers' exposures to foot marching and load-carriage activities, therefore, include both training and deployment scenarios. Evaluations have shown that foot marching and load-carriage activities are associated with injuries and that injury risk increases as the duration of the activity increases.^{5, 18} (Also see Appendix C). Primary exposure factors include load weight, frequency, distance, and speed of march. Intensity may be a factor of load weight or speed. Variations to these factors depend on mission; unit training; and fitness levels, equipment, and terrain. Available data provides the following exposure related considerations:

- Current training loads typically range from 40 to 100 pounds and distances of 2 to 12 miles. Speed may vary depending on terrain and time of day, though an example goal is 12 miles in 3 hours (4 miles per hour (mph)).^{2, 3} However, because load weight, distances, frequencies, terrains, and equipment type are unit-level decisions, there is not a single required standard regimen for Army-wide foot-march training. Unit exposure data are very limited because documentation regarding these exposure factors for individual units has not been required.
- Improvements in weaponry, body armor, and other carried equipment have added to the typical military load.^{1, 3, 4, 8, 9} For example, during U.S. military operations in Afghanistan, infantry Soldiers carried an average load of 101 pounds, although different military occupational specialties within the unit carried loads ranging between 87 and 127 pounds.^{4, 8} Combat units, such as Infantry and Cavalry, were found to wear heavier loads for longer periods of time.⁵ Specific occupations or teams known to carry some of the highest weights include anti-armor teams, mortar teams, and radio operators.^{3, 6, 9}
[Note: Consistent collection of unit-level deployment and training exposure factors (load weight, frequency, distance, speed, terrain, and equipment) is needed to differentiate exposure groups.]
- In addition to heavier load weights, the distances and frequency of foot-march training may be increasing in some units to supplement a reduction in physical training (PT) runs. This is only a hypothesis since current data are not adequate to assess the relationship. The hypothesis is based on anecdotal reports and because current Army physical readiness training (PRT) doctrine reduces emphasis on PT run distances and frequency in order to reduce

historically high rates of lower-extremity injuries.^{21, 22} Not only have prior studies found both running and foot marching to be leading causes of Army training injuries, the highest injury rates highest among trainees have been associated with greatest total footsteps (see Appendix C). [*Note: Assessing this hypothesis requires further exploration of the combined impact of exposures from both running and marching on lower extremities injuries.*]

Injury Types. In general, available data indicate *lower extremities* (legs, knees, feet) and the back are the two body regions most frequently affected by foot marching and load-carriage activities.^{1, 18} Injury types include blisters, various musculoskeletal injuries (e.g., localized pain, strains, sprains, and stress fractures), and various nerve compression injuries that cause numbness, tingling, pain, weakness, or temporary paralysis.^{1, 4, 5, 11, 18} Variations in study findings are expected to be due in large part to different data collection sources and methods. For example, some studies have used medical assets in the field to diagnose injuries,^{1,4} other studies rely on hospitalization/medical records,¹⁸ while others use self-reported (survey) data.^{5, 23, 24} The following are specific injuries that have been associated with load-carriage activities listed by body region:

- **Feet.** Foot injuries have been found to be the predominant body region injured in foot marching in field studies that have used medical assessments for identification of injuries.^{1, 3,4,6} Specific foot injuries that have been reported by these past studies include—
 - *Foot blisters:* Though not a musculoskeletal injury, past studies and reviews have described foot blisters as one of the most common marching injuries.^{1, 2,3, 6} Knapik 2015¹ cites studies where foot blisters or foot hotspots (as blister precursors) accounted for 35% to 50% of all the injuries. Though the severity of these injuries is less well documented, a survey of U.S Soldiers in Iraq in 2003 to 2004 reported that 33% had experienced foot blisters during deployment and that 11% had sought medical care for treatment of these blisters.^{1,4}
 - *Nerve compression foot-injuries: Metatarsalgia* (pain in middle or front of sole) is a foot nerve injury associated with foot marching that has been identified in field studies where medical examinations identified injuries. Another condition known as *digital paresthetica* affects the toes.^{1,6}
 - *Stress fractures of the foot:* Stress fractures, also termed “march fractures”, have been attributed to long distance foot-marching activities. Over the years and changes in training patterns, stress fractures may also be associated with other training activities such as running. The extent that

marching activities causes or compounds risk of foot stress fractures is not clear.^{1,6}

- Knee, Lower Leg, Ankle. When aggregated with the feet, studies have described lower extremities as the leading body region injured during foot marching activities.^{1,3,18} These injuries include gradual onset of pain (especially in the knee) and strains and sprains, as well as more traumatic ankle injuries from falls. Stress fractures to the lower leg have also been reported.¹ Knee and ankle combined account for a quarter to over one half of foot marching injuries.^{1, 18, 23}
- Back. Besides lower extremities, studies have consistently identified the back as one of the most common body regions injured by foot marching and load-carriage activities. Back injury rates from foot marching reported in the literature have been 23%,¹ 26%,¹⁸ and 27% from recent self-reported data.²³
- Other Body Region-specific Injuries Associated with Foot-Marching.^{1,4,6}
 - *Pelvis:* Pelvic stress fractures have been associated with foot marching.
 - *Thigh:* The nerve compression injury, known as *meralgia paresthetica*, has been associated with pressure from hip belts, harnesses, or body armor.
 - *Shoulder or arms:* A condition known as “ruck sack palsy” (or *Brachial plexus palsy*) that is caused from straps compressing nerves in shoulders is a specific diagnosis attributed to load carriage and foot marching.
- Environmental Injuries. Though not as well studied, environmental injuries such as those attributed to hot-weather and exertion (exertional heat illness (EHI)) or cold weather-related injuries, as well as animal and insect bites, have also been attributed to foot-marching activities.¹⁸ These types of injuries may need to be more consistently captured in future studies.

Injury Severity. While some injuries or symptoms will develop during the marching activity, others may develop or be more clearly recognized post-marching. Studies have shown many injuries continue 1 to 15 days post-march activity.^{1,4} While only a small portion of studied injuries appear to require Soldiers to discontinue the march, the severity of injuries can vary.^{1,4} More recent self-reported data indicate marching-related injuries in one infantry unit ranged from 36 to 69 limited duty days per injury.²³ From blisters and sore muscles to more debilitating stress fractures and neuropathies, the impacts may range from short-term pain to days of limited duty or restricted physical activity to even permanent disabilities as well as varying levels of

medical treatment.^{2,6,7} More consistent metrics of injury severity could improve future assessments.

Injury Mechanism. Acute traumatic injuries may result from a fall or trip (such as twisting an ankle) or immediate pain or muscle strain from lifting a rucksack inappropriately. A recent study¹⁸ that used medical records of Australian military found 62% of injuries were from muscle stress (non-traumatic overuse), and 21% were from falls/twists. The falls caused 77% of the ankle injuries, which were the second leading body region to back. Other mechanisms noted include heat stress (7%), followed by rubbing/chafing which only accounted for 5% of injuries (such as pain, blisters, *metatarsalgia*). Non-traumatic overuse injuries (such as pain, strains/sprains) that occur more gradually over time have also been noted in recent self-reported data from an infantry unit.²³

Foot Marching and Load-Carriage Injury Data.

Though historic data have provided insights into the type of injuries and some risk factors associated with foot marching and load-carriage activities, recent data are increasingly showing that these activities are among the leading causes of injuries in Army initial entry training (IET), operational infantry units, and among deployment population. Findings are largely supported by non-U.S. military assessments.

Injuries in U.S. Army IET. While physical training and running in particular are the most commonly reported causes of injuries in IET, risks of injury per hours of exposure are higher for road marching. For example, leading causes of injury in IET for men and women have been reported as physical training (such as running, calisthenics, and so forth: 24% of injuries to women, 26% to men); road marching (23% for women, 24% for men); and obstacle courses (4% for women, 5% for men). This same data show an incidence of 2.2 injuries per 1,000 man-hours of physical training, compared to a rate of 10.5 per 1,000 man-hours of marching. Therefore, the risk of experiencing a road-marching injury is about 5 times higher per hour of exposure than experiencing an injury during physical training.^{22, 25}

Injuries in the U.S. Army Infantry. Among infantry Soldiers, marching has been reported to be the second highest activity associated with injuries ranging from 17% to 22%, exceeded only by running injuries which ranged from 27%–30%.^{23, 24} Limited-duty days resulting from road-marching-related injuries were the highest among all activities in these studies, ranging from 36 to 69 limited duty days per injury.^{23, 24} The top three most common injured body regions associated with road marching were back injuries (27%), knee injuries (22%), and ankle injuries (19%). The most commonly cited mechanisms of injury during road marching were overuse/repetitive activity (62%), followed by single overexertion/over-extension (16%), and falling (9%).²³

Another analysis of 355 infantry Soldiers carrying approximately 46 kilograms (kg) (101 pounds) for 20 kilometers (km) (12.4 mile) road march, reported 91 injuries (approximately 50% blisters and 50% musculoskeletal injuries) recorded by medical providers.¹ Assuming an estimated rate of 4 miles per hour, this results in a rate of about 90 injuries per 1000 man-hours.

Injuries in Deployment Settings. Wearing loads, especially for greater than 4 hours, have increased the risk of injury in several studies of thousands of deployed Soldiers.^{14, 26-28} In combination with lifting, wearing heavy gear, including armor, has even been identified as one of the most frequent causes of non-battle musculoskeletal injuries during deployments, accounting for 14% to 20% of injuries.²⁹⁻³⁰ Wearing more than 30 pounds of armor and/or equipment has been shown to increase the risk of injury by 64 to 50% with the risk continuing to increase as the load increased.^{26, 27, 31} The same trend was noted when the weights worn were expressed as a percentage of the Soldier's body weight; wearing 10% of body weight increased risk of injury 30 to 100%.^{26,27,31} The data also demonstrate that injury risk increases with increasing duration that body armor is worn.^{5,4,26}

Non-U.S. Load-Carriage Injury Assessments. Though load-carriage and marching have been a subject of past international military study, studies have focused primarily on the relationship between marching and personnel fitness or performance levels (such as the speed of marches). Studies that have evaluated the relationship with injuries have been more limited. The 2009 Research and Technology Organization (RTO) of the North Atlantic Treaty Organization (NATO) report (*Optimizing Operational Physical Fitness*)³ has documented findings and mission-related testing and training recommendations of an international group of military research experts. The variability among study designs, population characteristics, and physical training program designs made it difficult to discern specific training recommendations that would both optimize marching performance and also minimize risk of injury. Despite the variability of studies, similar types of load-carriage injuries and general risk factors (such as low fitness levels, body size/gender, lack of a progressive program, excessive weight or distance) were noted.³ More recently, a study of Australian Army Soldiers found 404 (21%) of 1,954 injury records were attributed to load carriage and concluded that load carriage is a substantial source of injury risk. The majority were lower back or lower extremity musculoskeletal injuries.¹⁸ A separate review of past Australian and British data also concluded that back and lower-extremity injuries, including blisters, are predominant.^{1,4} Though less robust and reflecting a somewhat older population carrying lighter loads, Civilian hiker data also reflect these types of injuries as leading injury problems.^{1,4}

Military scientists generally agree that to maximize military marching performance, load-carriage training needs to elicit performance improvements without increasing

injury.^{3,12,13} Research suggests that a balanced training regime should include some form of foot-march and load-carriage training but with concurrent, non-marching physical training aimed at enhancing aerobic fitness, muscular strength, and muscular endurance.^{3,2,13,32} However, findings have not been consistent enough to determine threshold-marching distances or amounts of other types of physical activity in such a training program. Some research suggests that load-carriage and foot-march training should focus less on distance and frequency and more on higher intensity (that is, speed and weight of carried loads).^{3,12,13} It has been pointed out, however, that higher intensity must be balanced with proper gradual progression and rest periods, in combination with other forms of physical training. March distances and frequency should especially be balanced with other activities that place repetitive stress on lower-extremities such as distance running.^{3,12,13}

Risk Factors.

Various factors can increase Soldiers risk of developing a load carriage or marching-related injury. While future investigation into these factors is expected to provide stronger evidence, current data suggest the following contribute to injury risk:

- **Individual Physical Factors.** Because load-carriage alters biomechanical posture, individual body size, bone structure, gender, age, prior injury, and fitness levels may predispose some Soldiers to be at greater risk of injuries. Some of these factors cannot be modified. For example, those of smaller build, which includes women, appear to be at greater risk of stress fractures.^{1, 13, 33} (Also see Appendix C). Other marching injuries, such as back injuries, may occur to women of smaller frame due to the design of equipment.⁷ Doctrine also suggests females may be more likely to hyperextend their necks leading to injuries.² Other factors that may increase risk of injury, such as poor physical fitness levels and muscle mass may be improved through training.^{1-3,13 33}
- **Training Program Parameters.** The design of a foot-march training program may provide opportunities for preventing injuries.^{2-4,9,10} Though available information does not provide adequate evidence for recommending a specific program, elements of a training program that contribute to injury risks have been identified. These include—
 - *Load weight:* Current load weights, including armor, described by NATO-countries range from 36 to 68 kg (80 to 150 pounds).⁴ It is acknowledged that these weights far exceed the maximum of 30% to 45% of body weight previously identified for optimal Soldier performance in combat conditions. While preferred weights (40 to 60 pounds) would allow better

performance,⁴ current deployment data show that even loads exceeding 10% of body weight (about 20 pounds, which is approximately equal to 10% of the average 180-pound Soldier) can begin to increase injury risk.^{3,5}

- *Distance, frequency (number marching sessions per week or month), and speed:* As has been shown with running, these factors contribute to the overall amount of the activity, which affects risk.³⁴ Available data have shown that two to four long-distance marches a month can provide equal performance improvement, while greater frequencies may pose greater risk especially from overuse conditions.¹² March-training distances used by NATO countries range from 5 to 20 km (3 to 12 miles).⁴ Though Army doctrine prescribes longer ‘goal-march’ distances of 12 miles, this distance may be reflect historic operations and not be necessary for all units.^{2,3} Though it has not been scientifically proven, it is also hypothesized that running with carried loads (e.g., speeds greater than 3 to 4 mph) may increase risk of injury. For example, anecdotal reports of injuries attributed to the training practice of “ruck-running” while carrying full loads are a concern (personal communication, between Ms. V. Hauschild, APHC Injury Prevention Program and MAJ Chris Nunn, Chief, Doctrine Branch, Doctrine and Collective Training Division Directorate of Training and Doctrine, U.S. Army Maneuver Center of Excellence (MCOE), April 25, 2016).
- *Progression:* Gradual progression of training has been shown to reduce the occurrence of running-related injuries as well as heat-related injuries in military trainee populations.²² Rapidly increasing load weight, distance, and speed of march training have been found to increase risk, especially in persons with individual personal risk factors such as low fitness levels.^{1-3,12,13}
- *Terrain:* Stresses on the body can be exacerbated by types of terrain especially steep rocky hills, sand, or snow.^{1-4,17,18}

- Equipment.

- *Boots, socks, and footcare.* Feet are especially prone to injuries during marching due to the repetitive rubbing on the skin, which can be exacerbated by ill-fitting footwear or improper footcare. Properly fitted boots, properly cut toe nails, and use of synthetic as opposed to cotton socks can prevent blister injuries. The APHC (Prov) Blister Prevention Factsheet (2015) provides additional details regarding risks and the means to reduce occurrence and severity of these injuries.³⁵
- *Backpack/Rucksack:*^{1,2,4,6}
 - *Type:* In addition to the heavy loads imposed by wearing body armor and carrying supplies such as ammunition and water, an additional load is often carried in a backpack (or rucksack). (See Appendix B). Heavy armor alone can alter a person's center of gravity. Rucksack loads tend to increase forward lean, which may increase the risk of back injuries. Though doctrine describes the option of front-back double packs, which can reduce back strain, these are not considered conducive to movements needed for most military tasks.² Soldiers can use different pack frames to change load distribution; though, the best equipment and distribution depends on a person's size and the type of terrain. The current Army pack is the **Modular Lightweight Load-Carrying Equipment (MOLLE)**.² The MOLLE includes a main rucksack with lightweight external frame, adjustable shoulder straps, waist belt, and a vest with several pockets and detachable compartments to allow unit-specific customization. Some aspects of its design may not accommodate all body sizes and shapes.⁷
 - *Packing:* Packing items in pockets and vests can lighten the load on the back and may help prevent awkward twisting or falls while accessing common items. When preparing for marches on even terrain, current guidance is to place heavier weights higher in the pack for more upright stance; for hilly or uneven terrain, a more broadly distributed load may help with stabilization.^{1,2,4,16}
 - *Sternum, shoulder, and waist/hip straps and armor.* Soldiers can adjust this equipment for better load distribution and to shift load strain to different parts of the body. For example, a properly adjusted hip strap can take 30% of the load, which can reduce strain on the back. Proper use of the sternum straps can move load strain to different parts of the

shoulder and reduce the probability of *rucksack palsy*. Some limitations to straps may not accommodate all body sizes and shapes.⁷

- *Donning and doffing*: Soldiers should be taught proper technique for picking up and putting on specific types of heavy loads and equipment to avoid sudden injury.²

CONCLUSIONS

The efficiency and effectiveness with which Soldiers conduct load-carriage and foot-marching activities are critical to military operations and, thus, must be a component of training. This training should optimize Soldiers' performance without increasing injury risk.

Foot marching with carried loads will always present a risk of injury to Soldiers; however, excessive load weight, inadequate progression in loaded march training, excessive frequencies and/or distances, inadequately balanced PT programs, and/or inappropriate use of available equipment may contribute to high rates of load-march-related injuries in IET and operational unit training.

Training, tactics, techniques, and equipment to reduce foot-marching and load-carriage injuries have not been adequately studied to provide specific- and proven evidence-based training recommendations.

RECOMMENDATIONS

Additional studies can improve the evidence for specific foot-marching and load-carriage injury prevention strategies. Future studies will be especially useful if they—

- Use consistent operational definitions of injuries (types, severity, mechanisms).
- Collect information regarding unit-specific foot-marching exposures (i.e., load weights, frequency, distances, speed) as well as terrain and equipment types (e.g., armor, packs, packing protocols).
- Assess relationships with exposures to other physical activity activities, especially load-bearing activities such as running, and resistance training.
- Provide comparable data using standardized definitions and terms to assess differences in specific training protocols.

In the interim, the following are suggested by APHC (Prov) as good practice guidelines:

- **Minimize load to what is necessary.** Per doctrine, the specific requirements need to be determined at the lowest operational unit level.² Carts, vehicles, and modification to logistic plans should be used whenever possible to reduce the load weights and distances carried by Soldiers.
- **Use the equipment appropriately.** Unit leaders should instruct and monitor Soldiers to ensure—
 - Proper use of the MOLLE system, including donning and doffing and adjustment of straps and belts to help redistribute loads and reduce strain.
 - Loads, straps, and armor are shifted by Soldiers if pain or numbness is noted.
 - Packing order in rucksacks is based on expected terrain.
 - Use of pockets is maximized without overweighting vest or inhibiting movement.
 - Proper footcare,² including use of properly fitted boots, proper cutting of toenails, use of synthetic socks, and keeping feet as dry as possible.
- **Limit frequency of foot-march training.** Marches every 10 to 14 days combined with a balanced PRT program may provide optimal performance with the least risk of injury. Because exceeding four marches a month may unnecessarily increase risk, training regimens should not exceed one distance march a week. Unit mission, baseline fitness levels, other physical activities and training, as well as terrain and climate must also be considered.
- **Balance foot march distances with training intensity (load weight and speed).** Distance goals should meet realistic operational requirements of the units. March distances less than 10 miles (6 to 8 miles) may be adequate for many units. The intensity may be more important but should also be designed to meet load weights and terrain environments expected for unit mission. Running with carried loads may unnecessarily increase risk of injury, so speeds greater than 3 to 4 mph are not recommended. It is recommended that “ruck-running” be avoided.
- **Progress gradually.** Gradual progression of activity has been shown to reduce the occurrence of injuries in populations not used to new physical demand levels, such as IET or newly arrived Soldiers not acclimated to the environment or running regimen. For runners, a common progression “rule of thumb” is to increase frequency, distance, or speed by no more than 10% to avoid injury or re-injury.³⁶ This same concept can be applied to load weight, distance, and speed in foot marching programs.² These factors along with unit mission, baseline fitness

levels, other physical training activities, as well as terrain and climate should be considered when designing of a foot march training and maintenance program.^{2,3,5}

- Optimal progression periods have been described as 2 to 6 months depending on individual, unit, and environmental factors. Twelve-week training programs common in the Army are within this range but should build intensity and distance separately and gradually (e.g., 10% each week). Unit and individual fitness levels, weather, and terrain should also be considered. Individuals recovering from injury or illness must train within limits of their medical profile and should then be afforded a progressive train-up period twice the length of their profile.²
- Because scientific evidence is not adequate to discern a single optimal Army-wide progression program, recommendations can only be general. For example, while maintaining 3-mph speed, load weights for uninitiated trainees might begin at 20 pounds (~18 pounds would increase the energy cost of an average 180 lbs Soldier 10%) and progress to 40, then to 60, and higher if needed. Progression target distances increasing speed, frequency and loads progressively between targets might be 2, 5, 10, up to 12 miles depending on unit mission. Alternate days for increasing load weight (intensity) and distance/duration (e.g., increase in distance accompanied by a decrease on load weight). Unit leaders should document their specific march-progression plans prior to implementation and coordinate with their unit master fitness trainer or brigade physical therapist.²
- **Balance foot-march training with other non-load-bearing PRT activities.** Soldiers need foot-march training to enhance combat performance, but marching should be balanced with other forms of PT and adequate recovery. PRT doctrine²¹ emphasizes a balanced training program of aerobic fitness, muscular strength, muscular endurance, agility, and balance exercises. Leaders are cautioned to avoid replacing reduced distance PT running with an excessive increase in distance-loaded marching. Leaders should consider coordinating with their unit master fitness trainer or brigade physical therapist to develop an Army physical training program that is best suited for their unit.²

TIP No. 12-054-0616

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Dated: May 2016

APPENDIX A

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TIP No. 12-054-0616

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TIP No. 12-054-0616

APPENDIX B

DEPICTION OF LOAD WEIGHTS WORN AND CARRIED

Protection and equipment are necessary, but the weight adds up

The U.S military has long struggled to balance the need for body armor to protect against attacks with minimizing weight so a soldier's movements are not hindered when under fire. The Army combat load is described by three general categories in Army doctrine: Fighting Load (recommended 48 pound maximum weight), Approach Load (maximum recommend weight 72 pounds), and the Emergency Approach Load (which should be a rare event, can be 120 pounds or more, and may need to be carried for several days over long distances). Additional equipment and weights are required for certain types of units and Soldiers.

Even with the lighter equipment referred to as the Modular Lightweight Load Carry Equipment (MOLLE), the basic fighting load of a typical U.S Army infantry Soldier has been estimated at more than 65 pounds, over 15 pounds heavier than the recommended maximal weight. Approach march loads exceeding 95 pounds have been carried for several days. Though some MOLLE redesigns and lighter-weight vests that include ballistic plates to protect vital organs but less protection of extremities have been made available since 2009, the overall carried items and weights carried during deployments to Afghanistan region have remained similar this past decade. During a 2012 project by the USAPHC it was again found that the numerous items carried by the Soldier can easily add up to over 100 pounds. The figures below show examples of typical weights carried or worn by Army Soldiers.

Basic Uniform		Fighting Load		Approach Load	
= 10 pounds*		Uniform + 35* pounds basic protection + 25 water and equipment = 70*pounds		Fighting Load + 32*pounds = 102* pounds	
Boots	4	Full Body armor w various ballistics plates and protective inserts	25*	Assault rucksack with attachments	9
Jacket & Trouser	3	Helmet	3	Hydration bladder	5
Rigger belt	0.5	M4 carbine/M16	7	Mortar round	4
Patches, ID tag & card	0.5	Ammunition	9	Poncho and extra clothing	5
Cap and eye wear	0.5	Water	7	Meals ready to eat (MREs), 2	3
Under wear, shirt, socks	1	MOLLE carrier vest w pouches	2	Medical IV fluid bag	1.5
Miscellaneous (watch, ear plugs)	0.5	Grenade	.5	Personal hygiene kit	2.5
		Night vision equipment	3	Rope, and other small item equipment	2
		First aid kit	1.5		
		Flashlight, other equipment	2		



(Photos courtesy Program Executive Office Soldier)

* Weights are rounded and examples only - actual weights may vary depending on size/version/manufacturer; several additional items may also be required (e.g., Hooligan tool (10 pounds), bolt cutters (1 pound), metal detector (3 pounds), or munitions such as Claymore mine (7 pounds) M249 ammunition (7 pounds) and even heavier items for certain units (e.g., radio operator, mortar gunner). Also, because protective armor inserts are removable, body armor weight and helmet alone can be 18-40 pounds.

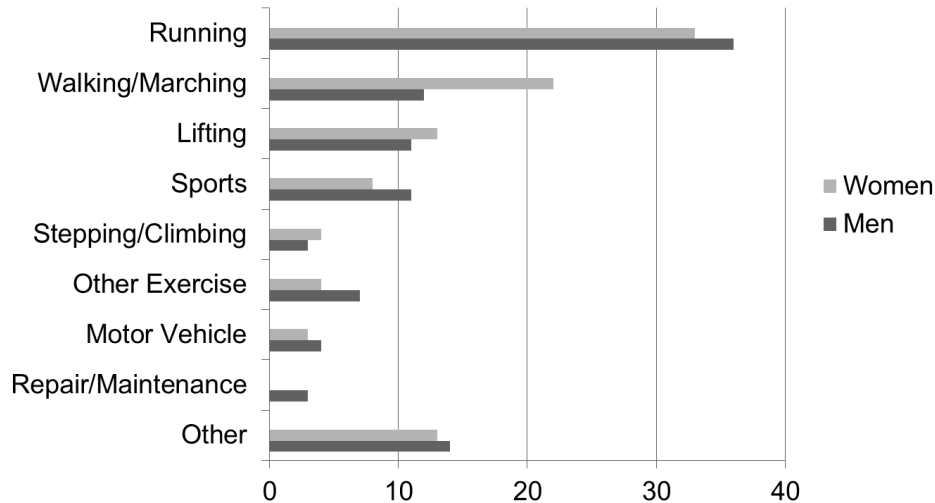
Sources: "The Modern Warrior's Combat Load", Dismounted Operations in Afghanistan April - May 2003 U.S. Army Center for Army Lessons Learned, 2003. <http://www.thedonovan.com/archives/modernwarriorload/ModernWarriorsCombatLoadReport.pdf>; "Lightening the Load." Naval Research Advisory Committee (Bachkosky, J. et al). Arlington, VA 2007. <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA528364>; Jones B et al. Development of a New Army Standardized Physical Readiness Test, January 2012 – December 2013. PHR No. 12-01-1214, U.S. Army Public Health Command, Aberdeen Proving Ground MD, 2015. Image concept adapted from "The Weight of War," Bernton, Hal, with graphic by Mark Nowlin, the Seattle Times 2.12.2011.

TIP No. 12-054-0616

APPENDIX C
SELECTED DEPICTIONS
OF
SCIENTIFIC LITERATURE

Selected slides from “*Emerging Findings from Military Human Performance Optimization and Injury Prevention Program Evaluations*,” presentation by Dr. Bruce Jones, MD, MPH at Mid-Atlantic Regional Conference (MARC)-American CSM Annual, Harrisburg, PA, 1 November 2014.

C-1. Distribution (%) of Injury Activity Causes In Non-Deployed Infantry Unit*



n = 1,198 (Men 1,078, Women 120). Then unpublished data presented by Dr. Bruce Jones, AIPH, MARC-ASCM, November 2014 (see recent PHC reports ^{23, 24})

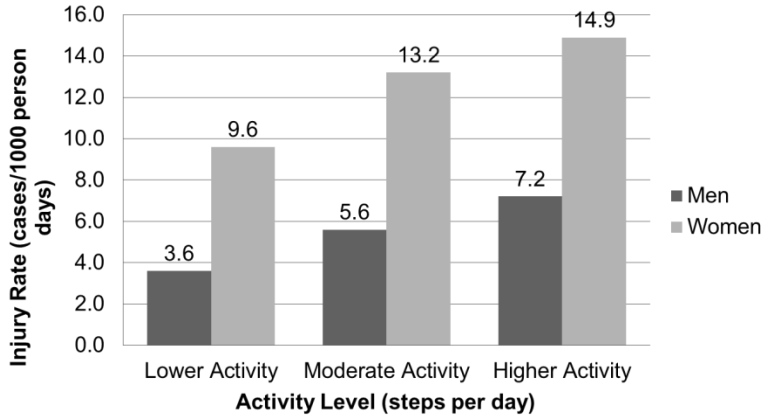
C-2. Crude Risks of Injury per Training Hours for Military Activities (BCT), 2010-2011

Military Training Activity	Risk per 1,000 man-hrs	Relative Rate
Physical Training	2.2	1.0
Road Marching	10.5	4.8
Obstacle Course	16.5	7.5

N = 5,894 (Men = 3,481, Women = 2,413)

Adapted from Knapik J, et al. Activities Associated With Injuries in Initial Entry Training. *Military Medicine*, 2013, Vol 178 5:500.

C-3. Injury Risks of Trainees During Basic Combat Training (BCT) by Footsteps per Day

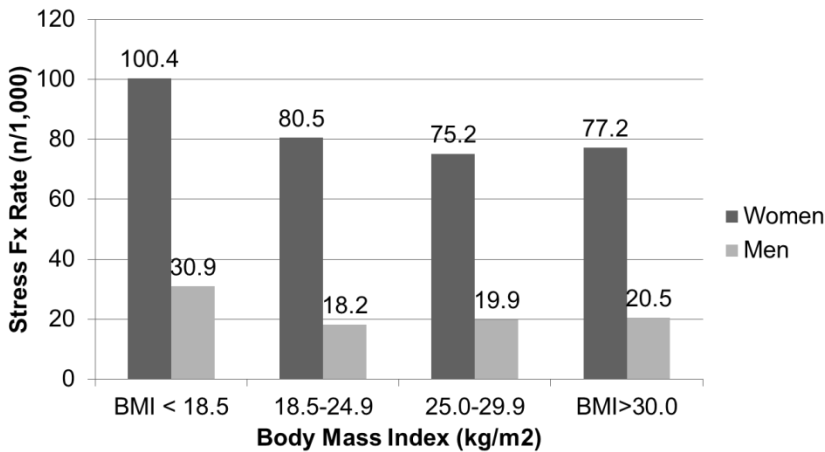


Men n=1174, Women n=898

Average # of footsteps per day: Lower=14,772 ± 400; Moderate=16,346 ± 768; Higher=17,948 ± 550

Source: Knapik J et al. Association Between Ambulatory Physical Activity and Injuries During United States Army Basic Combat Training. *Journal of Physical Activity and Health*, 2011, 8:496 -502.

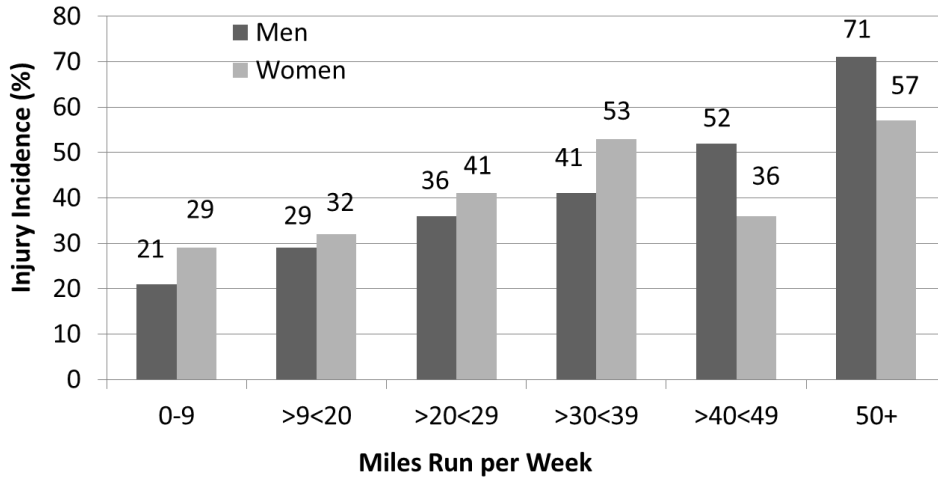
C-4. Body Composition (BMI) and Rates of Stress Fractures Among Female & Male Army Trainees



n = 583,651 Army recruits (Women 107,906 & Men 475,745)

Source: Knapik J et al. Stress Fracture Risk Factors in Basic Combat Training, 2012. *Int J Sports Med*, 33: 940-946.

C-5. Injuries per Year among Men and Women by Miles Run per Week



Source: Koplan JP, Powell KE, Sikes RK. An epidemiologic study of the benefits and risks of running. *JAMA*; 248:3118, 1982.