Differences in Injuries during Road Marching among Male and Female U.S. Army Soldiers

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Abstract

Purpose: Road marching is an essential element of military physical training that can result in injury. This study compared road marching injuries among men and women in a large population of U.S. Army soldiers.

Methods: Injuries occurring during the previous 12 months were collected by survey for 4,238 male soldiers and 960 female soldiers, as part of baseline data collection for a larger project investigating physical training programs and injury risk. Road marching-related injuries were identified by cause reported in surveys. Two-sample t-tests were used to compare injury-related factors by sex. Road marching-related injury types and injured body regions were summarized by sex. Relative risk of road marching-related injury among women compared with men was calculated.

Results: Women were shorter, had higher body fat, lower aerobic performance, and carried a greater proportion of their weight during road marching compared with men ($p < 0.05$). Men reported greater physical training time, marching loads, and more tobacco use ($p < 0.05$). Overall, 111 road marching-related injuries were reported (n=91 injuries among men (4% of injuries), n=20 injuries among women (3% of injuries)). Injuries to the lower extremities were common during road marching for both sexes, but the rate of hip injuries attributed to road marching was six times higher among women (12 per 1,000 women vs 2 per 1,000 men, $p < 0.01$). Road marching injuries also resulted in more limited duty days for women (mean ± SD, 44 ± 46 days for women, 36 ± 43 days for men).

Conclusions: Observed differences in injury-related factors among male and female soldiers (e.g., body fat, tobacco use, fitness, physical training, and weight carried during road marching) suggest that these factors contributed to differing distributions of injuries during road marching. Recommendations suggested by previous research to carry less than 30% body weight during road marching should be followed, especially for soldiers of smaller stature as they are more likely to experience gait adaptations and physiologic effects that increase risk of lower extremity injuries. Load carriage weights relative to lean body weight should be considered in future studies.

Military Impact: As road marching is a common soldiering task and women comprise 15% of the U.S. Army population, understanding differences in road marching-related injuries and injury risks between sexes is imperative to better inform injury prevention strategies for all soldiers.

Background

- Road marching has been reported as a leading activity associated with injury in many previous studies of military members.[1,2,3]
- Marching with a load significantly alters physiologic responses, such as: increased flexion angles in the trunk, hip, and knee; increased hip and ankle range of motion; increased hip and knee extension moments; increased muscle activation of lower limbs and trunk; increased forward inclination of trunk; increased ground reaction forces; and decreased stride length.[4-6]
- Previous studies of road marching injuries among military members have primarily reported on men and have not focused on women.[7] However, women represented 15% of the U.S. Army in 2021[1] and female soldiers have historically experienced higher injury rates than men.[1,8,9]
- The purpose of this analysis was to compare road marching injury details and factors that impact road marching injury risk by sex in a large population of U.S. Army soldiers.

Methods

- Data collection
  - An electronic survey was administered to 28,482 active duty U.S. Army soldiers from October 2018-April 2019, as part of an ongoing evaluation.
  - Respondents reported demographics, performance on the most recent Army Physical Fitness Test (APFT), activities related to unit and personal physical training , road marching participation, health behaviors like tobacco use and sleep hygiene, injuries, and details about recent injuries.
- Data analysis
  - Responses to survey questions about road marching participation during unit and personal physical training (average monthly frequency, average distance per session, and average weight carried per session) were used to calculate additional road marching exposure variables: average percent body weight carried, lean body mass carried, and average pound-miles per month.
  - Two-sample t-tests and chi-square tests were used to compare demographic, physical characteristics, road marching exposure, and health behavior variables for men and women. Injury rates and relative risks (RRs) of injury were calculated for men and women. Statistical significance was identified by $p<0.05$ and confidence intervals not including 1.00.

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Results

- A total of 5,198 respondents completed surveys, accounting for 18% of the surveyed population.
  - Eighty two percent of respondents were men, with an average age of 29 (±8) years.
- More than one-third of respondents (42%) reported a total of 3,129 injuries during the previous 12 months.
  - Four percent of injuries were reported to be associated with road marching (n=111), representing 4% of all injuries among men (n=91) and 3% of all injuries among women (n=20).
- Two-sample t-tests were used to compare injury-related factors by sex. **Table 1**
  - Statistically significant differences between sexes ($p<0.05$) were observed for all characteristics except age, hours slept per night, and distance marched per road marching session.
  - On average, women were shorter, had higher body fat, had lower aerobic performance, and carried a greater proportion of their weight during road marching. Men reported higher overall physical training (minutes of unit and personal physical training per week), higher road marching loads (pound-miles per month), and a higher proportion of tobacco use.
- Leading injury types and injured body regions associated with road marching were summarized. **Table 2**
  - Due to low counts, reporting is limited to categories containing three or more injuries with associated limited duty days.
  - Lower extremity injuries were frequently associated with limited duty among both sexes, and back injuries were also associated with limited duty for men.
  - Hip injuries were more prevalent among women (25% of reported road marching injuries) than men (5%), and hip injuries among women also resulted in more days of limited duty on average (64 days) than those among men (20 days).
- Among respondents who reported road marching, injury rates during road marching were compared by sex. **Table 3**
  - The rate of hip injuries during road marching among women was statistically significantly higher ($p<0.05$) than the rate of hip injuries among men.
  - Rates of any road marching injuries, road marching injuries resulting in limited duty, and strained muscles were also higher among women, though observed differences between sexes did not reach statistical significance perhaps due to low counts among women.
  - Rates of other injury types and injured body regions did not occur frequently enough among both sexes in this population to be compared.

Table 1. Demographics, physical characteristics, health behaviors, and road marching characteristics among surveyed soldiers by sex

	Male n=4,238 survey respondents	Female n=960 survey respondents
Demographics and physical characteristics		
Age (years)	28.8 ± 7.9	28.3 ± 7.3
Height (inches)	70.1 ± 3.2	64.9 ± 3.3*
Weight (pounds)	184.1 ± 27.6	146.8 ± 21.3*
BMI[λ] (kg/m2)	26.4 ± 3.5	24.5 ± 3.1*
Body Fat[¥] (%)	20.8 ± 4.4	31.9 ± 4.2*
Lean body mass[¥] (pounds)	144.8 ± 16.0	99.2 ± 10.0*
Aerobic fitness (U.S. Army Physical Fitness Test two-mile run time, minutes)	15.1 ± 1.5 n=3,750	17.4 ± 1.7* n=811
Health behaviors		
Physical training load (total unit and personal PT minutes per week)	640.4 ± 500.9 n=4,110	537.4 ± 442.1* n=899
Ever used tobacco[α] (%)	42.2	21.6*
Current tobacco users[α] (%)	8.1	3.9*
Average sleep (hours per night)	6.1 ± 1.3	6.1 ± 1.4
Road marching characteristics[μ], (only respondents who reported road marching participation; n=2,641 men, n=428 women)		
Road march frequency (sessions per month)	3.0 ± 2.5	2.7 ± 2.4*
Average distance marched (miles per session)	6.7 ± 4.3	6.5 ± 4.2
Average weight carried (pounds per session)	39.3 ± 9.4	34.2 ± 8.6*
Proportion body weight carried (%)	21.9 ± 6.2	24.1 ± 6.4*
Proportion lean body mass carried (%)	27.5 ± 7.1	35.2 ± 8.9*
Monthly road marching load[€] (pound-miles)	886.5 ± 1351.9	693.0 ± 1128.7*

*Significant difference between men and women ($p<0.05$)
[λ] BMI calculated from self-reported height and weight
[¥] Body fat percentage (and subsequently lean body mass) calculated using self-reported height, weight, age, and sex[10]
[A] Current and lifetime tobacco use includes cigarettes, smokeless tobacco, and e-cigarettes.
[μ] Reported road marching participation variables combine responses for unit physical training and personal physical training
[€] Road marching load calculated by multiplying self-reported marching frequency per month, average marching distance per session, and average weight carried.

Table 2. Leading injury types and injured body regions associated with road marching by sex (n= 111 injuries)

Male (91 injuries)				Female (20 injuries)			
Injury Types				***Injury Types***			
	n (% of all injuries)	n (% of injury type with Limited Duty)*	Average Limited Duty Days		n (% of all injuries)	n (% of injury type with Limited Duty)*	Average Limited Duty Days
Pain	18 (19%)	4 (18%)	26 days	**Strained muscle**	4 (20%)	3 (75%)	70 days
Sprained joint	14 (17%)	8 (60%)	26 days				
Strained muscle	14 (15%)	8 (54%)	23 days				
Tendonitis	5 (6%)	4 (80%)	51 days				
Total	**91 (100%)**	**52 (57%)**	**36 days (±43)**	**Total**	**20**	**10 (50%)**	**44 days (±46)**
Injured Body Regions				***Injured Body Regions***			
	n (% of all injuries)	n (% of injuries to body region with Limited Duty)*	Average Limited Duty Days		n (% of all injuries)	n (% of injuries to body region with Limited Duty)*	Average Limited Duty Days
Knee	20 (22%)	10 (50%)	49 days	**Hip**	5 (25%)	4 (80%)	64 days
Lower back	18 (20%)	9 (50%)	19 days	**Knee**	3 (15%)	3 (100%)	42 days
Ankle	17 (19%)	12 (71%)	41 days				
Lower leg	7 (8%)	5 (71%)	33 days				
Hip	5 (5%)	3 (60%)	20 days				
Upper back	**5 (5%)**	**3 (60%)**	**24 days**				
Total	**91**	**52 (57%)**	**36 days (±43)**	**Total**	**20**	**10 (50%)**	**44 days (±46)**
Combined Injury Type and Injured Body Region				***Combined Injury Type and Injured Body Region***			
	n (%)	n (% with Limited Duty)*	Average Limited Duty Days		n (%)	n (% with Limited Duty)*	Average Limited Duty Days
Sprained ankle	8 (9%)	4 (50%)	22 days	¥			
Strained lower back	5 (5%)	4 (80%)	13 days				
Runners' knee	5 (5%)	3 (60%)	23 days				
Total	**91**	**52 (57%)**	**36 days (±43)**	**Total**	**20**	**10 (50%)**	**44 days (±46)**

*Data are reported for a category if ≥3 injuries with Limited Duty were reported
[¥] All injury type/injured body region combinations had <3 injuries with Limited Duty

Table 3. Rates of injury types and injured body regions associated with road marching by sex (n= 111 injuries)

	Male			Female			Relative risk of road marching injury Female : Male (95% CI)
	# Injuries	# Road marching participants	Rate of Injuries per 1,000 soldiers	# Injuries	# Road marching participants	Rate of Injuries per 1,000 soldiers	
Any road marching injury	91	2,677	34	20	441	45	1.33 (0.82-2.17)
Any road marching injury with limited duty	52	2,677	19	10	441	23	1.17 (0.59-2.30)
By Injury Type*							
Strained muscle	14	2,677	5	4	441	9	1.73 (0.57-5.27)
By Injured Body Region*							
Hip	5	2,677	2	5	441	11	**6.07 (1.76-20.97)[¥]**
Knee	20	2,677	7	3	441	7	0.91 (0.27-3.06)

*Only injury types and body regions shown for women in Table 2 were included
[¥] Statistically significant difference ($p<0.05$)

Limitations

- Survey responses are subject to recall bias.
- Additional factors like prior injury, occupation, road marching exposure, road marching experience, marching gradient and terrain, and weather conditions also impact energy expenditure and injury risk during road marching.
- Though there were more female road matching participants in this population than have previously been reported in most studies, the number was small enough to limit the ability to explore multivariable logistic regression risk factor analyses.

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Conclusions

- In these operational U.S. Army units, men and women experienced a different distribution of injuries associated with road marching.
  - Women experienced more limited duty related to road marching injuries and a higher prevalence of hip injuries, compared to men.
- Evidence suggests that injury risks are associated with physiological differences, rather than sex alone.
  - Greater strength and power are associated with better performance on high intensity tasks like load carriage,[11] so men may be at a greater physiologic advantage for road marching tasks than women, on average.
  - Soldiers of smaller stature and lower muscle strength may bear a greater relative load during road marching than larger soldiers, which could lead to increased joint loading and decreased ability to adapt gait biomechanics.[7,8]
- Soldiers should carry personalized loads that are less than 30% of body weight, when possible, to minimize risk of lower extremity injuries.
- Future studies with larger populations of both sexes should investigate adjusted road marching injury risk factors for both sexes and explore recommendations for load weights based on lean body mass.