Injury Risk and Performance among Soldiers Wearing Minimalist Running Shoes Compared to Traditional Running Shoes

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ABSTRACT

Minimalist running shoes (MRS) are lightweight, extremely flexible and have little to no cushioning. It has been thought that MRS will enhance running performance and decrease injury risk. **PURPOSE:** To compare physical characteristics, fitness performance metrics, and injury risks associated with Soldiers wearing MRS and those wearing traditional running shoes (TRS). **METHODS:** Participants were men in a U.S. Army Brigade Combat Team (n=1332). Physical characteristics and Army Physical Fitness Test (APFT) data were obtained by survey. Fitness performance testing was administered at the brigade and the types of footwear worn were identified by visual inspection. Shoe types were categorized into 2 groups: TRS (stability, cushioning, motion control) and MRS. Injuries from the previous 12 months were obtained from the Defense Medical Surveillance System. A t-test was used to determine mean differences between personal characteristics and fitness performance metrics by shoe type (MRS vs. TRS). Hazard ratios (HR) and 95% confidence intervals (95%CI) were calculated to determine predictors of injury risk. **RESULTS:** A majority of Soldiers wore cushioning shoes (57%), followed by stability shoes (24%), MRS (17%), and motion control shoes (2%). Soldiers wearing MRS were younger than those wearing TRS (24.3±5.4 years vs. 25.3±4.8 years, p<0.01), performed more push-ups (69.1±13.5 reps vs. 64.2±13.4 reps, p<0.01), more sit-ups (71.6±11reps vs. 68.3±12.1 reps, p<0.01), ran faster during the 2-mile run (14.5±1.5 min. vs. 14.8±1.6 min., p=0.01), performed better on the vertical jump test (23.5±4.2 in. vs.22.6±4.4 in., p<0.01), performed more pull-ups (7.7±5.2 reps vs.6.2±4.4 reps, p<0.01), completed the 300 yard shuttle run faster (70.1±8.1 sec. vs.71.8±9.1 sec., p=0.03), and scored higher on the Functional Movement Screening test (17±2.2 points vs. 16.3±2.5 points, p<0.01). When controlling for personal characteristics including physical fitness, there was no difference in injury risk in the previous 12 months between Soldiers wearing MRS compared to Soldiers wearing TRS (HR (MRS vs.TRS) 95%CI): 1.03 (0.80-1.33, p=0.82). **CONCLUSIONS:** Soldiers who chose to wear MRS were younger and had higher physical performance scores compared to Soldiers wearing TRS. Controlling for these differences, use of MRS does not appear to be associated with higher or lower injury risk in this population.

INTRODUCTION

Over a one-year period approximately 35-52% of recreational and competitive runners may experience a running related injury. [1 2 3 4] It has been proposed that minimalist running shoes (MRS) will enhance running performance and decrease injury risk. Running in minimalist shoes is thought to encourage a forefoot or mid-foot strike which may reduce the initial impact force on landing. Some trainers and sports medicine practitioners claim minimalist shoes decrease risk of injury and increase performance, but there is currently no scientific evidence to support these claims.

Minimalist shoes can be classified into three sub-groups: the barefoot style shoe, the minimalist shoe and the transition shoe; these differ in amount of cushioning and degree of heel drop. [5 6] The purpose of this project was to compare Soldier personal characteristics, physical performance, and injury risks associated with minimalist running shoes (MRS) and traditional running shoes (TRS: stability, cushioning, and motion control).

METHODS

Participants

Participants were male Soldiers in a U.S. Army Brigade Combat Team (n=1332). The brigade consisted of two infantry battalions, a cavalry battalion, a field artillery battalion, a brigade support battalion and a brigade special troop battalion. Rosters were requested and obtained through the brigade Physical Therapist.

Surveys

Personal characteristics (e.g., gender, age, tobacco use, prior injury) including measures of physical fitness (e.g. body mass index, physical performance test results, miles run per week with unit, most recent Army physical fitness test (APFT) results) were obtained by survey. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²). Soldiers who smoked at least one cigarette in the last 30 days and smoked 100 or more cigarettes in their lifetime were identified as smokers.

Army Physical Fitness Test Results

The APFT consisted of three events: a 2-minute maximal effort push-up event, a 2-minute maximal effort sit-up event, and a 2-mile run performed for time. APFT event results (push-ups, sit-ups and 2-mile run) were converted into quartiles. The raw score from each event was then converted into points using scoring sheets. [7] Scoring sheets are age and gender specific. The maximum number of points is 100 per event or a total score of 300.

Injury and Demographic Data

The Armed Forces Health Surveillance Center provided Defense Medical Surveillance System data on Soldier demographics as well as visit dates and ICD-9 diagnosis codes (International Classification of Diseases 9th Revision) for all outpatient and hospitalization injury visits in the 12 months prior to survey administration. Injury incidence was calculated as the number of Soldiers with one or more injuries divided by the total number of Soldiers surveyed.

METHODS (Cont.)

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Fitness Performance Testing

The 300-yard shuttle run, vertical jump, pull-ups (maximum number that could be completed) and functional movement screening (FMS™) were performed by the brigade. FMS™ is a tool intended to predict injury in physically-active populations and involves seven tests: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability pushup, and rotary stability. Each FMS event is worth 1-3 points depending on how well the movement is performed. However if pain is associated with the event then a score of 0 would be given for that event. The maximum number of points achievable is 21.

Footwear

Footwear age was identified by Soldier interviews following survey completion. Footwear brand name and model were identified by visual inspection. Shoe type was identified as TRS (stability, cushioning, or motion control running shoes) or MRS (minimalist running shoes) based on manufacturer descriptions. The Soldiers were also asked if these were the shoes in which they typically ran. Only Soldiers who said "Yes" were included in the analysis.

Data Analysis

The Statistical Package for the Social Sciences (SPSS®), Version 18.0, was used for statistical analysis. Means and standard deviations (SD) were calculated for personal characteristics, physical fitness and physical fitness test results. An ANOVA and t-test were used to determine differences between personal characteristics and physical performance test results by shoe type. Potential injury risk factors, risk ratios and 95% confidence intervals (95%CI) were calculated using the last 12 months of injury data obtained from the AFHSC. Potential injury risk factors assessed included personal characteristics (age, rank, battalion, tobacco use, prior injury) and physical fitness (BMI, miles run per week during unit PT, APFT 2-mile run time). A multivariate Cox regression model was used to assess key predictors of injury risk. Hazard ratios and 95%CIs are presented for each potential risk factor (independent variables) for injury during the previous 12 months .

RESULTS

Descriptive Statistics

Soldiers were on average 25.1 ± 5.3 years of age and had an average BMI of 26.1 ± 3.5 kg/m². Overall injury incidence over the last 12 months was 43%. A majority of Soldiers wore cushioning shoes (57%), followed by stability shoes (24%), MRS (17%), and motion control shoes (2%).

Table 1 displays means and standard deviations by shoe type for personal characteristics and physical performance testing. Soldiers wearing MRS compared to Soldiers wearing TRS were younger and performed better on a majority of the physical performance tests.

Table 1. Personal Characteristics and Physical Performance by Specific Shoe Type

Shoe Type	Stability		Cushioning		Motion Control		Minimalist		ANOVA
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	p-value
Age	324	25.0±5.5	755	25.3±5.3	32	26.3±6.6	221	24.3±4.8	0.05
BMI	324	26.0±3.4	754	26.2±3.6	32	27.4±4.0	221	25.8±3.3	0.08
Miles Run per Week for Unit PT	284	9.4±6.3	671	9.2±6.2	27	8.1±4.6	194	10.1±7.1	0.25
2-Mile Run	302	14.6±1.6	683	14.9±1.6	30	15.4±1.5	204	14.5±1.5	<0.01
Push-Ups	309	65.0±13.2	703	63.9±13.5	31	61.4±13.7	208	69.1±13.5	<0.01
Sit-Ups	308	68.7±11.5	709	68.1±12.4	31	67.0±13.3	208	71.6±11.0	<0.01
Total APFT Score	137	243.0±34.9	315	235.7±39.4	15	228.9±36.6	86	247.4±36.4	0.03
300-Yard Shuttle Run	240	71.6±10.4	523	71.8±8.4	22	74.9±11.2	149	70.1±8.1	0.06
Vertical Jump	315	22.5±4.4	712	22.7±4.4	32	20.7±4.8	207	23.5±4.2	<0.01
Pull Ups	316	6.3±4.5	726	6.2±4.4	31	5.7±4.5	211	7.7±5.2	<0.01
FMS™	307	16.2±2.6	699	16.4±2.5	29	15.4±2.6	205	17.0±2.2	<0.01

RESULTS (Cont.)

Table 2 consolidates the information in Table 1 by grouping stability, cushioning, and motion control shoes into one group (TRS) and comparing this group to those who wore minimalist running shoes (MRS). Soldiers wearing minimalist shoes compared to Soldiers wearing TRS were younger and performed better on a majority of the physical fitness tests.

Table 2. Personal Characteristics and Physical Performance by Grouped Shoe Type, Traditional Running Shoes vs. Minimalist Running Shoes

Shoe Type	Traditional (TRS)		Minimalist (MRS)		T-Test
	n	Mean (SD)	n	Mean (SD)	p-value
Age	1111	25.3±5.4	221	24.3±4.8	<0.01
BMI	1110	26.1±3.5	221	25.8±3.3	0.24
Miles Run per Week for Unit PT	982	9.2±6.2	194	10.1±7.1	0.10
2-Mile Run	1015	14.8±1.62	204	14.5±1.5	0.01
Push-Ups	1043	64.2±13.4	208	69.1±13.5	<0.01
Sit-Ups	1048	68.3±12.1	208	71.6±11.0	<0.01
Total APFT Score	467	237.6±38.2	86	247.4±36.4	0.03
300-Yard Shuttle Run	785	71.8±9.1	149	70.1±8.1	0.03
Vertical Jump	1059	22.6±4.4	207	23.5±4.2	<0.01
Pull-Ups	1073	6.2±4.4	211	7.7±5.2	<0.01
FMS™	1035	16.3±2.5	205	17.0±2.2	<0.01

Table 3 displays unadjusted injury risk factors associated with running shoe type, personal characteristics and physical performance. Higher risks of injury were seen among Soldiers who were older, had a BMI ≥ 30 kg/m², were in the support battalions, were previously injured and performed poorly on the 2-mile run test.

Table 3. Unadjusted Association of Running Shoe Type, Personal Characteristics, and Physical Performance with Injury Risk among U.S. Army Soldiers

Variable	Variable Level	n	% Injured	Risk Ratio (95%CI)	p-value
Running Shoe Type	Stability	324	40%	1.00	
	Cushioning	755	45%	1.10 (0.94-1.29)	0.21
	Motion Control	32	44%	1.08 (0.71-1.63)	0.73
	Minimalist	221	43%	1.05 (0.86-1.28)	0.66
Age of Shoe	< 6 months	558	44%	1.10 (0.92-1.31)	0.31
	6-12 months	201	43%	1.07 (0.89-1.29)	0.48
	1-2 years	96	40%	1.00	
	>2 years	28	43%	1.07 (0.78-1.47)	0.69
Age (years)	≤20	259	32%	1.00	
	21-25	564	44%	1.36 (1.11-1.65)	<0.01
	26-30	312	47%	1.44 (1.17-1.78)	<0.01
	31+	197	50%	1.53 (1.23-1.92)	<0.01
Rank	E1-E3	537	41%	1.00	
	E4-E6	689	45%	1.10 (0.96-1.25)	0.17
	E7-E9	34	47%	1.14 (0.79-1.65)	0.51
	O1-O3	68	37%	0.89 (0.64-1.23)	0.47
Battalion	Infantry 1	332	37%	1.00	
	Infantry 2	405	42%	1.11 (0.93-1.33)	0.25
	Calvary	174	43%	1.14 (0.91-1.42)	0.26
	Field artillery	108	46%	1.24 (0.97-1.59)	0.10
	BSB (Support)	73	59%	1.58 (1.24-2.00)	<0.01
	BSTB (Support)	198	52%	1.39 (1.15-1.69)	<0.01
	Headquarters	42	33%	0.89 (0.57-1.40)	0.61
Tobacco Use	Smoker	613	41%	1.00	
	NonSmoker	696	46%	1.11 (0.98-1.26)	0.09
BMI (kg/m²)	<25	473	40%	1.00	
	25-29.9	621	42%	1.05 (0.91-1.21)	0.52
	30+	230	53%	1.33 (1.13-1.56)	<0.01
Previous Injury	No	828	37%	1.00	
	Yes	504	54%	1.45 (1.29-1.64)	<0.01
Miles Run per Week during Unit PT	≤ 4 miles	350	42%	1.19 (0.98-1.45)	0.07
	4.1-7 miles	316	35%	1.00	
	7.1-10 miles	180	47%	1.32 (1.06-1.63)	0.01
	10+ miles	330	48%	1.35 (1.12-1.63)	<0.01
APFT 2-Mile Run Times (min.)	≤13.72	329	33%	1.00	
	13.73-14.75	317	39%	1.20 (0.98-1.48)	0.08
	14.76-15.83	327	40%	1.24 (1.01-1.52)	0.04
	15.84+	246	56%	1.74 (1.45-2.10)	<0.01

RESULTS (Cont.)

Table 4 displays the results of a multivariate Cox regression assessing risk factors associated with injury. Analysis showed that Soldiers who were older, in the field artillery or support battalions, previously injured, ran more miles per week with their unit, and performed poorly on the 2 mile run test were at a higher risk of injury. There were no differences found for shoe type and injury risk.

Table 4. Adjusted: Association of Running Shoe Type, Personal Characteristics, and Physical Performance with Injury Risk among U.S. Army Soldiers, Multivariate Regression Results

Variable	Variable Level	n	Hazard Ratios (95%CI)	p-value
Running Shoe Type	Stability	269	1.00	
	Cushioning	613	1.10 (0.87-1.39)	0.41
	Motion Control	25	0.88 (0.44-1.75)	0.71
	Minimalist	177	1.10 (0.81-1.48)	0.54
Age (years)	≤20	226	1.00	
	21-25	460	1.33 (1.01-1.75)	0.05
	26-30	248	1.33 (0.97-1.81)	0.08
	31+	150	1.42 (1.00-2.00)	0.05
BMI (kg/m²)	<25	405	1.00	
	25-29.9	505	0.88 (0.71-1.10)	0.27
	30+	174	1.05 (0.79-1.40)	0.74
Battalion	Infantry 1	288	1.00	
	Infantry 2	337	1.10 (0.84-1.44)	0.48
	Calvary	153	1.30 (0.94-1.79)	0.11
	Field artillery	75	1.48 (1.00-2.19)	0.05
	BSB (Support)	60	1.51 (1.01-2.27)	0.05
	BSTB (Support)	140	1.60 (1.18-2.17)	<0.01
	Headquarters	31	0.72 (0.36-1.43)	0.35
Tobacco Use	Non-Smoker	576	1.00	
	Smoker	508	1.08 (0.89-1.31)	0.46
Previous Injury	No	693	1.00	
	Yes	391	1.56 (1.29-1.90)	<0.01
Miles Run per Week during Unit PT	≤ 4 miles	316	1.27 (0.98-1.66)	0.07
	4.1-7 miles	295	1.00	
	7.1-10 miles	171	1.35 (1.00-1.82)	0.05
	10+ miles	302	1.43 (1.10-1.85)	<0.01
APFT 2-Mile Run Times	≤13.72	293	1.00	
	13.73-14.75	277	1.25 (0.94-1.66)	0.12
	14.76-15.83	299	1.27 (0.96-1.69)	0.09
	15.84+	215	1.94 (1.44-2.61)	<0.01

CONCLUSION

On average, U.S. Army Soldiers who chose to wear minimalist running shoes were younger and had higher physical performance scores. Injury risk did not differ between Soldiers who chose to wear minimalist running shoes during physical training and those who chose to wear traditional running shoes. Results suggest that Soldiers who are younger and more athletic are more likely to wear minimalist running shoes, and that use of MRS does not appear to be associated with higher or lower injury risk in this population.

1. Macera CA, Pate RR, Powell KE, Jackson KL, Kendrick JS, Craven TE. Predicting lower-extremity injuries among habitual runners. Archives of Internal Medicine 1989;49:2565-8.

2. Marti B, Vader JP, Minder CE, Abelin T. On the epidemiology of running injuries. The 1984 Bern Grand-Prix study. American Journal of Sports Medicine 1988;16:285-94.

3. Koplan JP, Powell KE, Sikes RK, Shirley RW, Campbell CC. An epidemiologic study of the benefits and risks of running. Journal of the American Medical Association 1982;248:3118-21.

4. Caspersen C, Powell K, Koplan J, Shirley R, Campbell C, Sikes R. The incidence of injuries and hazards in recreational and fitness runners. Medicine and Science in Sports and Exercise 1984;16:113-4.

5. Zero-Drop Shoes, 2011. Accessed on 23 April 2013 at http://www.runnersworld.com/barefoot-running-minimalism/run-minimally.)

6. Traditional Shoes vs. Minimalist Shoes, 2012, Accessed on 23 April 2013 at http://exercisesforinjuries.com/traditional-shoes-vs-minimalist-shoes.)

7. Physical P. Physical Fitness Training. U.S. Army Field Manual (FM) 21-20. Washington, D.C.: Headquarters, Department of the Army; 1992.

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