



# Better Fitness is Related to Lower Injury Risk in Male and Female Marines during Integrated Training



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## ABSTRACT

Background: The Secretary of Defense announced on 3 December 2015 his decision that all Combat arms be opened across all armed forces to females; however, it is unclear as to how the integration of females into ground combat occupational specialties may affect injury incurred during training. The Marine Corps assessed more than 35 studies on the potential impact of gender integration in the ground combat arms specialties and units that were previously restricted to female Marines. The purpose of this study was to determine if male and female Marines who met a male performance threshold on a comprehensive battery of physiological and musculoskeletal tests were less likely to sustain a musculoskeletal injury during the Marine Corps' Ground Combat Element Integrated Task Force.

Methods: A total of 302 Marines (age=22.49±2.67 yrs, height=173.34±8.61 cm, weight=76.14±12.19 kg) in the integrated force participated. Anthropometric data (height, weight, arm span, and leg length) along with the following were collected: body composition; aerobic capacity/lactate threshold during maximal treadmill testing; anaerobic power/capacity testing during a maximal 30-second cycle sprint; shoulder, trunk, knee, and ankle strength; balance testing; field-based power testing (medicine ball toss, standing broad jump, pro-agility); and select events from the Marine Corps Physical Fitness Test and Combat Fitness Test (crunches, maneuver under fire, movement to contact). The top 95% of male performance created: threshold attained on ≥60%, ≥70%, ≥80% and ≥90% of all tests. Injury status (injury/no injury) was prospectively tracked throughout integrated training. Chi-square tests were performed to assess the relationship between the threshold categories and injury status (p<0.05).

Results: Significant relationships were found between injury status and Marines who met or exceeded the threshold on ≥60% [29.9% vs. 54.1% injured in met vs. no met;  $\chi^2$  (1, N=302)=8.022, p=0.005], ≥70% [28.9% vs. 49.1%;  $\chi^2$  (1, N=302)=7.500, p=0.006, ≥80% [28.6% vs. 46.3%;  $\chi^2$  (1, N=302)=6.522, p=0.011, and ≥90% [26.6% vs. 46.3%;  $\chi^2$  (1, N=302)=8.948, p=0.003] of the tests.

Conclusion: Better fitness was associated with reduced risk of injury during integrated training. Participants who attained threshold on ≥60%, ≥70%, ≥80%, or ≥90% of the laboratory/field variables were less likely to sustain an injury during integrated training than those who did not. Both male and female Marines should focus on training to maximize the modifiable muscular and physiological characteristics, such as muscular strength/power, body composition, and aerobic/anaerobic fitness, in order to reduce the risk of injury during integrated training.

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## INTRODUCTION

- On 3 December 2015, the Secretary of Defense announced that all Combat arms be opened to females across all armed forces
- The Marine Corps has assessed more than 35 studies on the potential impact of gender integration in ground combat specialties and units that were previously restricted to female Marines
- It is unclear as to how integration of females into ground combat occupational specialties may affect injury incurred during training

- The purpose of this study was to determine if male and female Marines who met a male performance threshold on a comprehensive battery of physiological and musculoskeletal tests were less likely to sustain a musculoskeletal injury during the Marine Corps' Ground Combat Element Integrated Task Force

## EXPERIMENTAL DESIGN AND METHODS

- 302 Marines (Age: 22.5 ± 2.7 yrs, Height: 173.3 ± 8.6 cm, Mass: 76.1 ± 12.2 kg) in the Ground Combat Element Integrated Task Force participated

### Physiological and Musculoskeletal Assessments

- Body composition (BF%), fat mass, fat-free mass (Bod Pod, Cosmed, Chicago, IL) (Figure 1)
- Aerobic capacity (ml/min) measured during an incremental treadmill protocol to exhaustion (TrueOne 2400, Parvo Medics, Sandy, UT), along with lactate threshold (%VO2Max) (Lactate Pro®, Arkray, Inc, Kyoto, Japan) (Figure 2)
- Anaerobic Power/Capacity (W) measured during a Wingate cycling protocol (VeloTron Ergometer, RacerMate, Seattle, WA)
- Isokinetic strength (Nm) of the shoulder, trunk, and knee using concentric reciprocal contractions at 60 degrees/second (Biodex Multi-Joint System 3 Pro Biodex Medical Systems, Inc, Shirley, NY) (Figure 3)
- Isometric strength (kg) of the ankle using a handheld dynamometer (Lafayette Instruments, Lafayette, IN)
- Balance assessment (NeuroCom Balance Master, Natus Medical, Inc, Pleasanton, CA)
- Field-based testing (Medicine ball toss, standing broad jump, sit and reach, and Pro-Agility)
- Select events from the Marine Corps Physical Fitness Test and Combat Fitness Test (Abdominal crunches, maneuver under fire, movement to contact, and 3 mile run time)



Figure 1. Bod Pod Body Composition System



Figure 2. Maximal Oxygen Update/Lactate Threshold Testing



Figure 3. Isokinetic Knee Extension/Flexion Testing

### Performance Threshold

- The top 95% of male participants (5<sup>th</sup> percentile) for each variable was identified as the performance threshold
- The percent of variables where the performance threshold was met or exceeded was calculated for each participant, with participants categorized as attaining threshold on ≥60%, ≥70%, ≥80%, and ≥90% of all tests

### Injury Status

- All participants were prospectively followed throughout integrated training for musculoskeletal injury
- Participants were categorized according to prospective injury status (Injury vs. No Injury)

### Statistical Analyses

- Chi-square tests were performed to assess the relationship between the threshold categories and injury status
- Alpha was set at p<0.05 a priori

## RESULTS

- Means and standard deviations (SD) of select variables at each performance threshold level are presented in Table 1
- Significant relationships were found between injury status and Marines who met or exceeded the performance thresholds on ≥60%, ≥70%, ≥80%, and ≥90% of all tests (Table 2)

TABLE 1. Means (SD) of select variables at each performance threshold level

	Injury	Performance Threshold Met				Performance Threshold Not Met			
		≥ 60%	≥ 70%	≥ 80%	≥ 90%	≥ 60%	≥ 70%	≥ 80%	≥ 90%
Body Fat (%)	NO	20.0 (6.0)	19.6 (5.9)	19.3 (5.8)	19.3 (5.5)	23.8 (5.3)	24.1 (4.8)	23.9 (5.3)	23.2 (6.3)
	YES	20.1 (6.1)	19.5 (6.0)	19.4 (6.2)	18.6 (6.3)	25.3 (5.9)	24.9 (5.8)	24.3 (5.7)	24.2 (5.4)
Aerobic capacity (ml/min)	NO	3887.8 (624.5)	3980.4 (567.8)	4047.8 (522.7)	4047.1 (528.6)	2849.5 (303.5)	2866.9 (258.6)	2908.4 (272.1)	3054.6 (415.3)
	YES	3668.7 (560.2)	3767.7 (511.0)	3839.7 (458.7)	3885.0 (443.7)	2651.7 (256.3)	2709.8 (265.3)	2748.0 (299.8)	2915.8 (482.9)
Anaerobic power (W)	NO	980.1 (193.0)	1009.8 (175.6)	1029.3 (166.1)	1041.1 (157.4)	649.4 (79.4)	664.2 (77.5)	686.7 (87.7)	724.9 (142.4)
	YES	930.0 (194.4)	961.6 (183.1)	985.3 (173.8)	994.6 (169.4)	627.1 (64.5)	644.8 (77.0)	656.2 (80.8)	705.0 (152.2)
Trunk extension strength (Nm)	NO	250.5 (67.0)	256.9 (65.2)	261.9 (63.3)	264.8 (64.3)	142.7 (47.6)	158.1 (50.2)	164.8 (51.6)	175.8 (53.8)
	YES	238.9 (67.5)	249.2 (64.6)	257.9 (60.2)	263.6 (61.1)	148.9 (28.1)	154.2 (33.0)	154.5 (31.8)	168.1 (45.2)
Knee flexion strength (Nm)	NO	89.6 (20.5)	91.6 (20.1)	93.9 (18.4)	95.1 (17.5)	52.5 (14.1)	58.6 (14.0)	59.2 (14.8)	62.8 (102.0)
	YES	90.0 (20.6)	92.9 (20.4)	94.9 (20.1)	96.0 (20.7)	62.0 (9.9)	64.1 (9.7)	65.1 (9.8)	69.6 (14.5)

TABLE 2. Chi-square tests with percent of injured participants at each percent of performance threshold attained

	Percent Injured		$\chi^2$	p-value
	Performance Threshold Met	Performance Threshold Not Met		
≥ 60%	29.9%	54.1%	(1, N=302)=8.022	0.005
≥ 70%	28.9%	49.1%	(1, N=302)=7.500	0.006
≥ 80%	28.6%	46.3%	(1, N=302)=6.522	0.011
≥ 90%	26.6%	46.3%	(1, N=302)=8.948	0.003

## SUMMARY AND CONCLUSIONS

- Better fitness was associated with reduced risk of injury during integrated training
  - Participants who attained the performance threshold on ≥60%, ≥70%, ≥80%, and ≥90% of the laboratory/field assessments were significantly less likely to sustain an injury during integrated training than those who did not
- Both male and female Marines should focus on training to maximize modifiable physiological and musculoskeletal characteristics, such as body composition, aerobic/anaerobic fitness, and muscular strength/power, to reduce the risk of injury during integrated training

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