

# Body Composition of Soldiers: Inter-relationships with Physical Fitness, Injury Risk & Deployment



**U.S. ARMY PUBLIC HEALTH CENTER**



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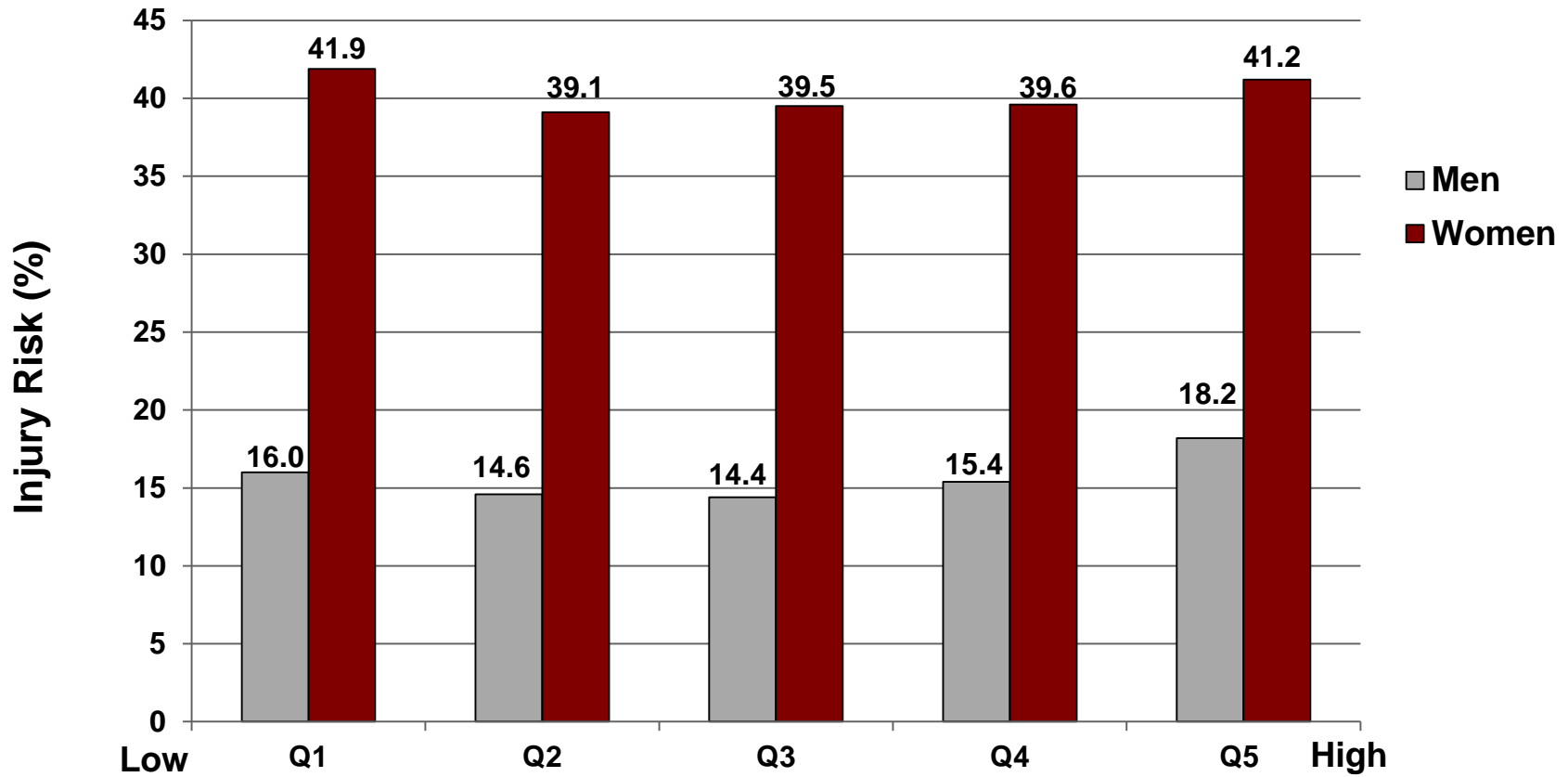
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- Use recent Army data to illustrate the complexity of the relationship of BMI, % body fat, physical fitness, and injury risks.
- Examine the effects of deployment to combat zones on body composition and physical fitness.

- What are the correlations of BMI with physical fitness and injury risk among Soldiers?
- What are the correlations of BMI with components of physical fitness and military task performance?
- What is the effect of deployment to areas of combat on body composition and physical fitness?
- What can we conclude from the data?

# **BMI, Physical Fitness & Injury Risks Among Army Recruits**

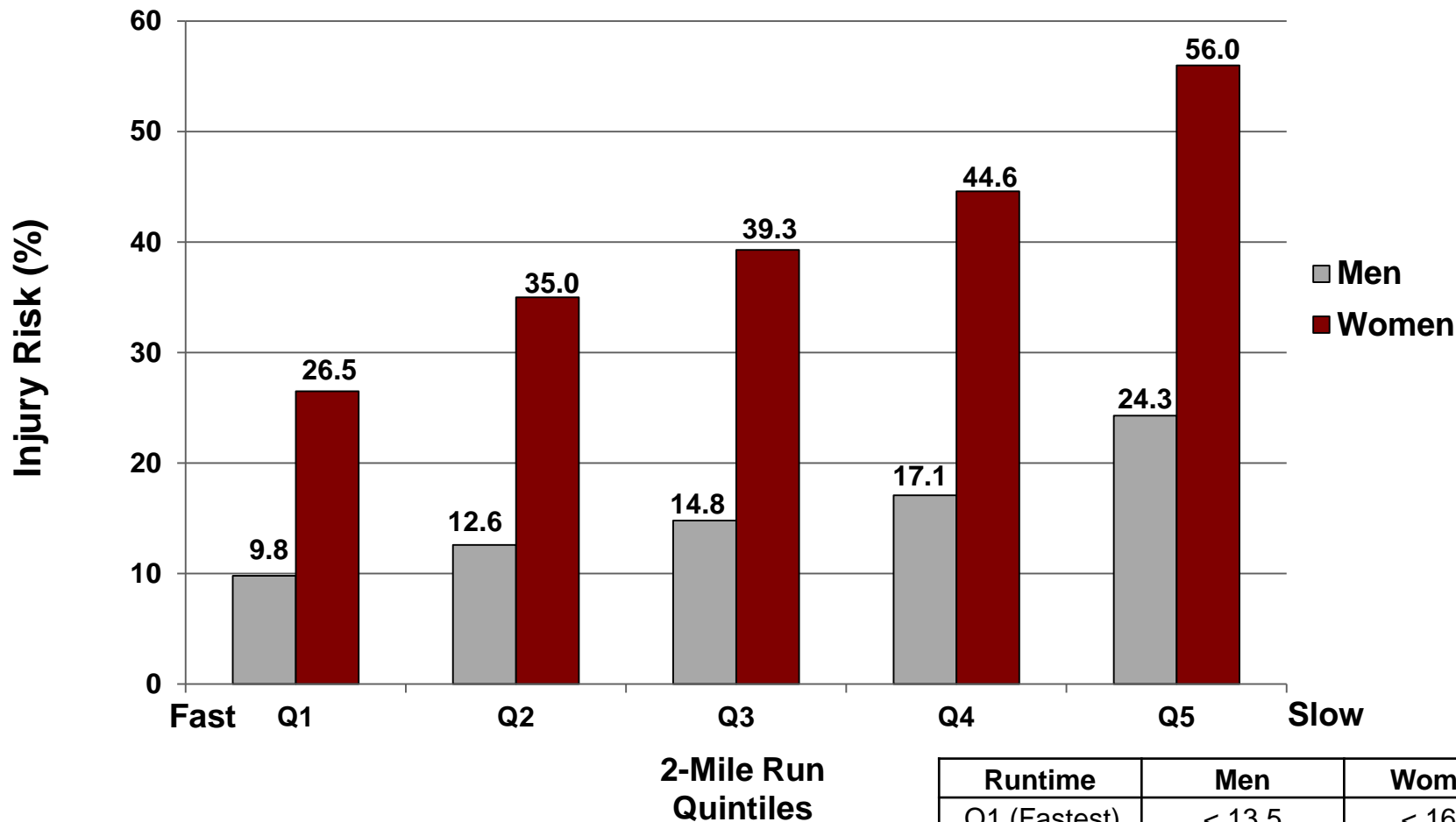
# Body Mass Index (BMI) and Injury Risk (%) for Men and Women in BCT



BMI	Men	Women
Q1 (Lowest)	<21.7	< 20.7
Q2	21.7-23.8	20.7 - 22.6
Q3	23.9-25.9	22.7- 24.2
Q4	26.0-28.3	24.3- 25.6
Q5 (Highest)	>28.3	>25.6

Jones BH et al., JSAMS, 2017  
 N = 184,598 (Men = 143,159, Women = 41,439)  
 RR Q1 vs Q5: Men (1.1, p<.001), Women (1.0, p=.36)  
 RR Q1 vs Q3: Men (1.1, p<.001), Women (1.1, p<.05)  
 RR Q5 vs Q3: Men (1.3, p<.001), Women (1.0, p<.05)

# Aerobic Endurance and Injury Risk (%) for Men and Women in BCT

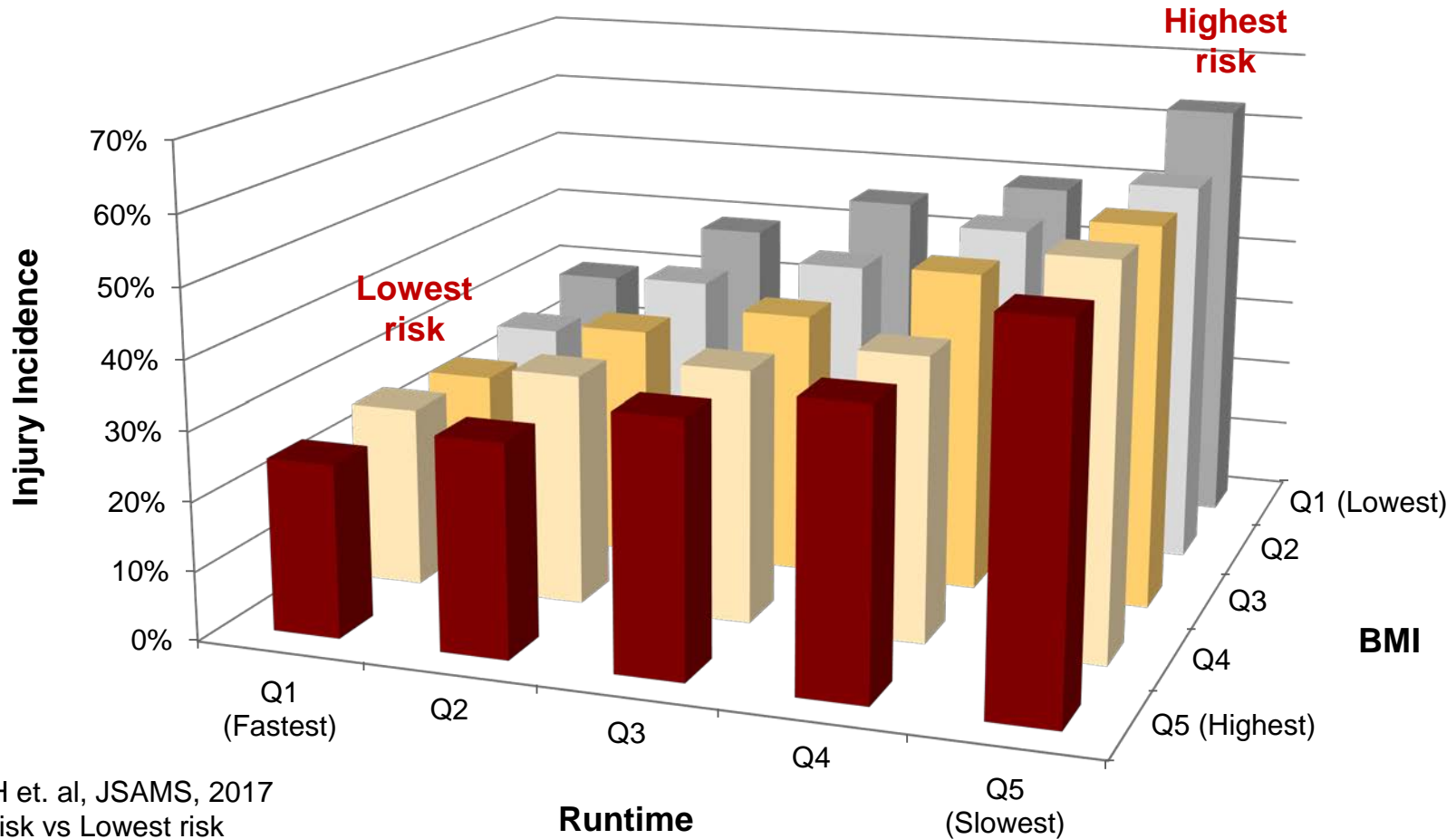


Jones BH et al., JSAMS, 2017  
 N = 184,598 (Men = 143,159, Women = 41,439)  
 RR Q1 vs Q5: Men (2.5, p<.001)  
 RR Q1 vs Q5: Women (2.1, p<.0001)

Runtime	Men	Women
Q1 (Fastest)	< 13.5	< 16.2
Q2	13.5 – 14.2	16.2 – 17.3
Q3	14.3 – 15.0	17.4 – 18.1
Q4	15.1 – 15.8	18.2 – 19.0
Q5 (Slowest)	>15.8	>19.0

# Injury Incidence by 2-Mile Run Time and BMI for Women in BCT

**Lowest risks are the most aerobically fit, middle to high BMI quintiles**  
**Highest risks are the lowest BMIs across all fitness levels**

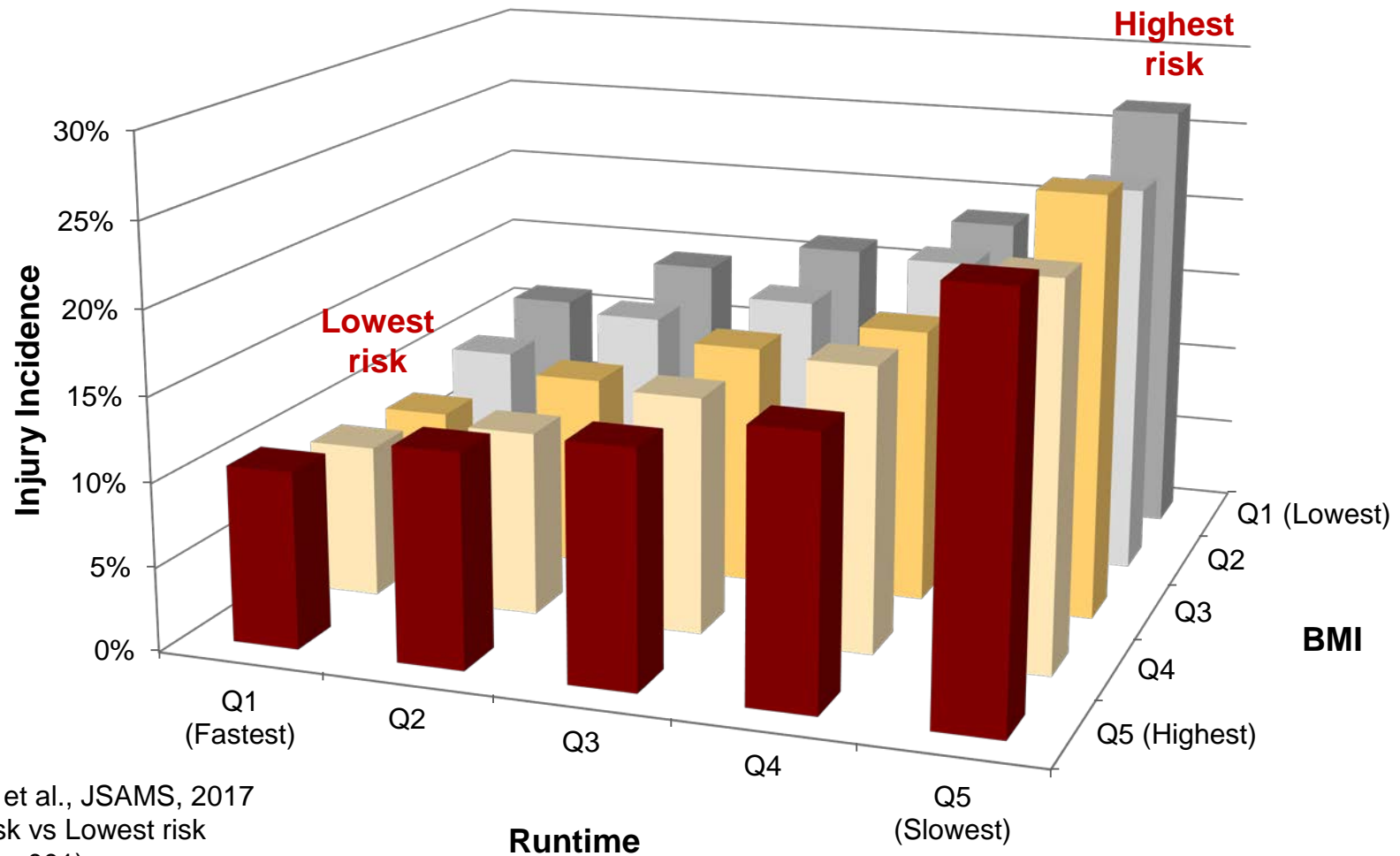


Jones BH et. al, JSAMS, 2017  
 Highest risk vs Lowest risk  
 RR=2.6 (p<.001)



# Injury Incidence by 2-Mile Run Time and BMI for Men in BCT

**Lowest risks are the most aerobically fit, middle to high BMI quintiles**  
**Highest risks are the lowest BMIs across all fitness levels**



Jones BH et al., JSAMS, 2017  
 Highest risk vs Lowest risk  
 RR=3.1 (p<.001)

- Association of BMI with injury risk is slightly bi-modal with low and high BMI groups at slightly higher risk than middle groups of men and women.
- Association of 2 mile run times with injury risk is an upward trend, as run-times get slower injury risks go up for men and women.
- Run-times stratified on level of BMI show:
  - Highest risk groups are men and women with the lowest BMIs and slowest run times.
  - Lowest risk group for women is the highest and second highest BMI with the fastest run times.
  - Lowest risk group for men is second highest BMI with fastest run time.

# BMI, Physical Fitness & Age of Soldiers in Operational Units



# Average BMI by Age and Average 2-Mile Run Time for Men in a Chemical Brigade



***As age increases, BMI and run times increase***

<b>Age</b>	<b>Average BMI<sup>a</sup> ± SD (n)</b>	<b>Average 2-Mile Run Time<sup>b</sup> ± SD (n)</b>
≤ 24 years	25.4 ± 3.6 (308)	14.4 ± 1.4 (283)
25-29 years	26.2 ± 3.7 (267)	14.8 ± 1.3 (229)
30-35 years	27.3 ± 4.0 (362)	15.2 ± 1.4 (201)
36+ years	27.2 ± 4.0 (254)	15.6 ± 1.5 (162)

<sup>a</sup> N = 1,191

<sup>b</sup> N = 875, 2-mile run times in minutes and fractions of a minute

Source: Rappole et al., JSAMS, 2017



# Average BMI by 2-Mile Run Time for Men in a Chemical Brigade



***As run time increases, BMI increases***

<b>2-Mile Run Time</b>	<b>Average BMI <math>\pm</math> SD (n)</b>
$\leq 13.92$ minutes	24.5 $\pm$ 2.9 (218)
13.93-14.92 minutes	25.3 $\pm$ 3.3 (211)
14.93-15.90 minutes	26.6 $\pm$ 3.5 (214)
15.91 + minutes	27.9 $\pm$ 3.8 (209)

N = 852, 2-mile run times in minutes and fractions of a minute

Source: Rappole et al., JSAMS, 2017



# Risk of Injury by Quartiles of Age and BMI for Men in a Chemical Brigade



**Male Soldiers with highest BMIs in the older age groups (25+ years) plus those in the oldest age group (36+ years) are at greatest risk of injury**

BMI	≤ 24 years	25-29 years	30-35 years	36+ years	Total
≤ 23.9	39% (99)	37% (76)	52% (52)	50% (46)	43% (273)
24.0-26.5	35% (95)	46% (78)	40% (55)	56% (45)	43% (273)
26.6-29.0	34% (70)*	36% (58)	54% (69)	57% (79)	46% (276)
29.1+	50% (44)	64% (55)	59% (87)	63% (84)	60% (270)
Total	38% (308)	45% (267)	52% (263)	58% (254)	(1,092)

\* Reference

Source: Rappole et al., JSAMS, 2017



# Risk of Injury by Quartiles of 2-Mile Run Time and BMI for Men in a Chemical Brigade



**Male Soldiers with lowest BMIs and slowest run times plus those with highest BMIs and slowest run times are at greatest risk of injury**

BMI	≤ 13.92 minutes	13.93-14.92 minutes	14.93-15.90 minutes	15.91 + minutes	Total
≤ 23.9	34% (88)*	38% (76)	48% (40)	68% (25)	42% (229)
24.0-26.5	40% (76)	34% (64)	48% (65)	43% (44)	41% (249)
26.6-29.0	35% (43)	38% (50)	39% (62)	61% (64)	44% (219)
29.1+	54% (13)	50% (26)	56% (50)	60% (83)	57% (172)
Total	37% (220)	38% (216)	47% (217)	58% (216)	(869)

\* Reference  
 Mean age = 29.8 yrs (+/- 7.4); mean BMI = 26.5 kg/m<sup>2</sup> (+/- 3.9)

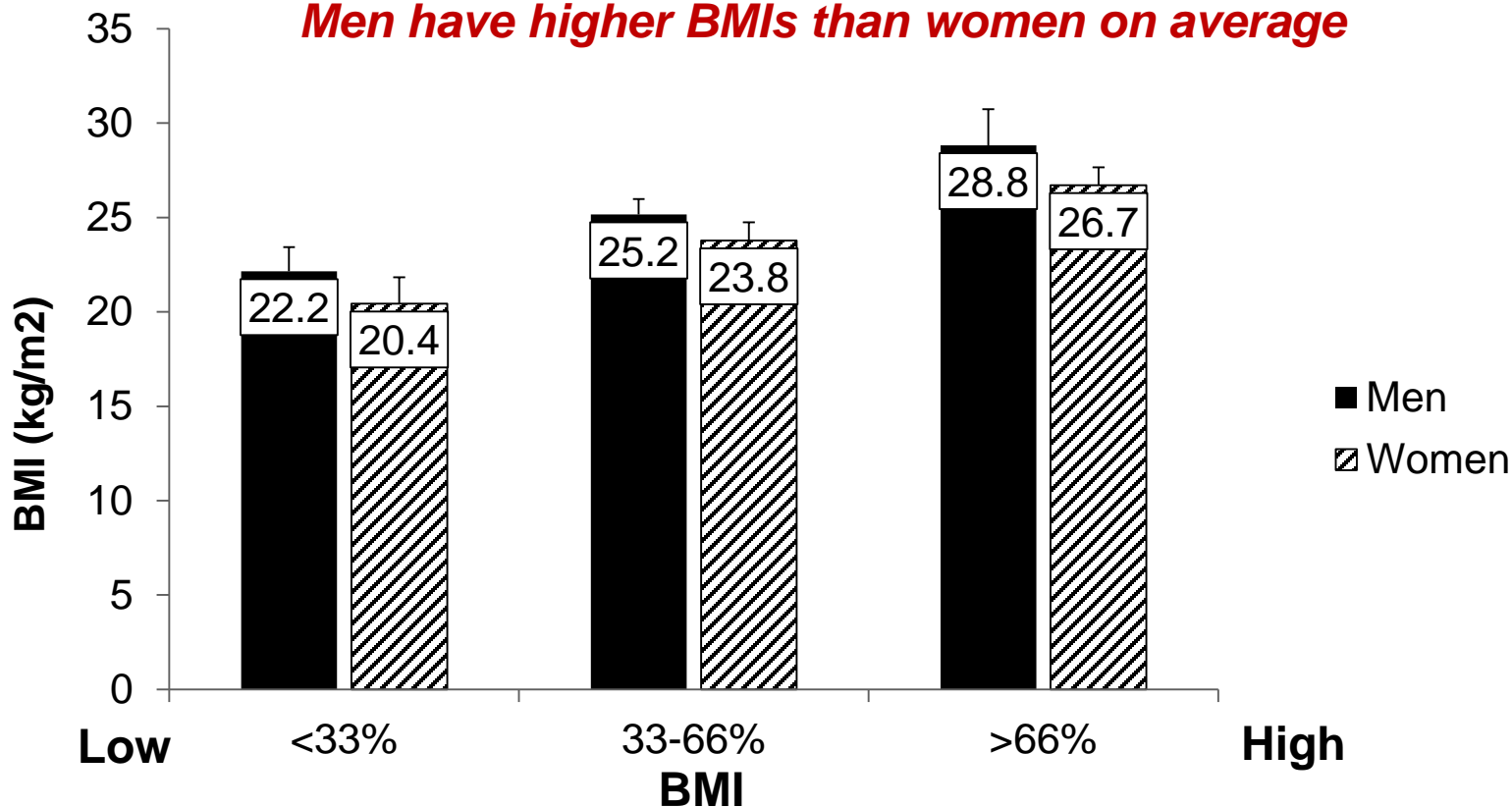
Source: Rappole et al., JSAMS, 2017

- As age increases, BMI and 2-mile run time increase for men.
- As BMI increases, 2-mile run time increases for men.
- Age groups stratified on level of BMI show:
  - Highest injury risk group for men is the highest BMIs in the older age groups (25+ years) and those in the oldest age group (35+ years).
- Run times stratified on level of BMI show:
  - Highest injury risk group for men is the lowest and highest BMIs with the slowest run times.



# **Correlations of BMI & Height with Physical Fitness & Military Performance**

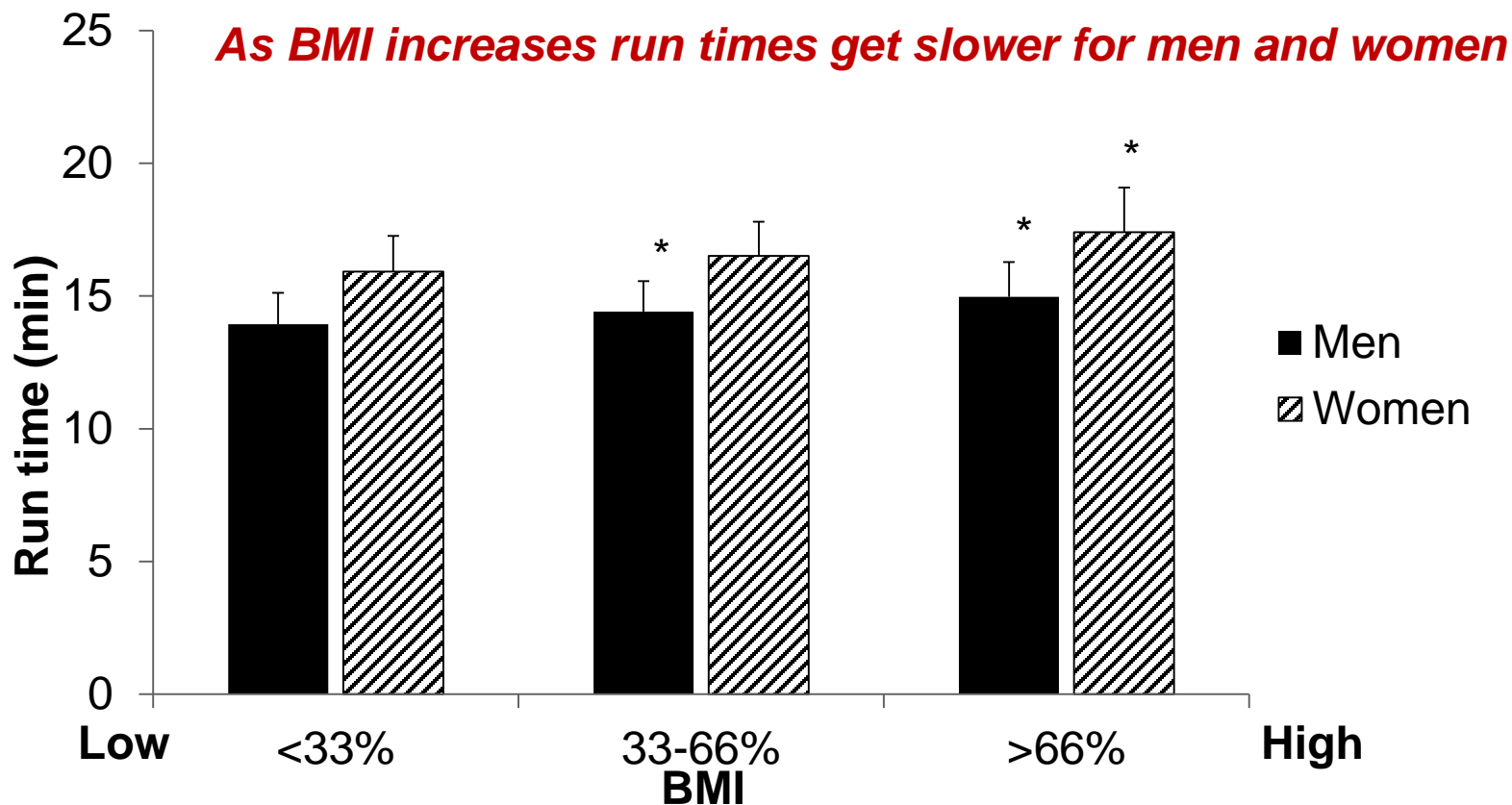
*Men have higher BMIs than women on average*



	<33%	33-66%	>66%
<b>Men (kg/m<sup>2</sup>)</b> n=275	18.6 - 23.8 n=91	23.9 - 26.5 n=90	26.6 - 34.9 n=94
<b>Women (kg/m<sup>2</sup>)</b> n=46	16.9 - 22.1 n=15	22.1 - 25.4 n=16	25.6 - 28.6 n=15

Source: Pierce J et al., JSAMS, 2017

# BMI vs. Aerobic Performance (APFT 2-mile Run Time)

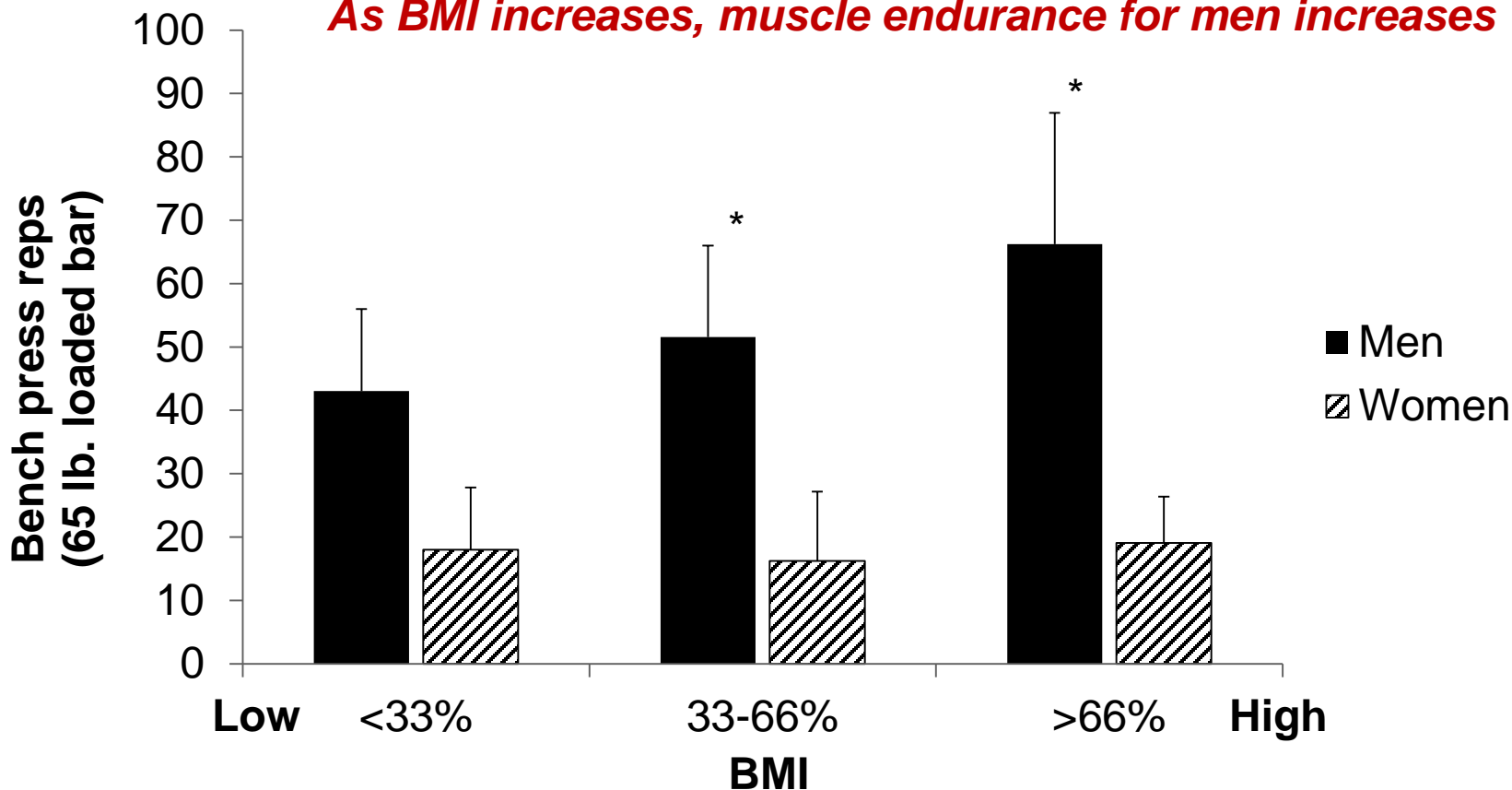


	BMI			ANOVA
<b>Men (kg/m<sup>2</sup>)</b>	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9	.000
n=275	n=91	n=90	n=94	
<b>Women (kg/m<sup>2</sup>)</b>	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6	.025
n=46	n=15	n=16	n=15	

Data are mean ± SD; \*P≤0.05 vs. tertile 1 (T1) (<33%)

Source: Pierce J et al., JSAMS, 2017

**As BMI increases, muscle endurance for men increases**

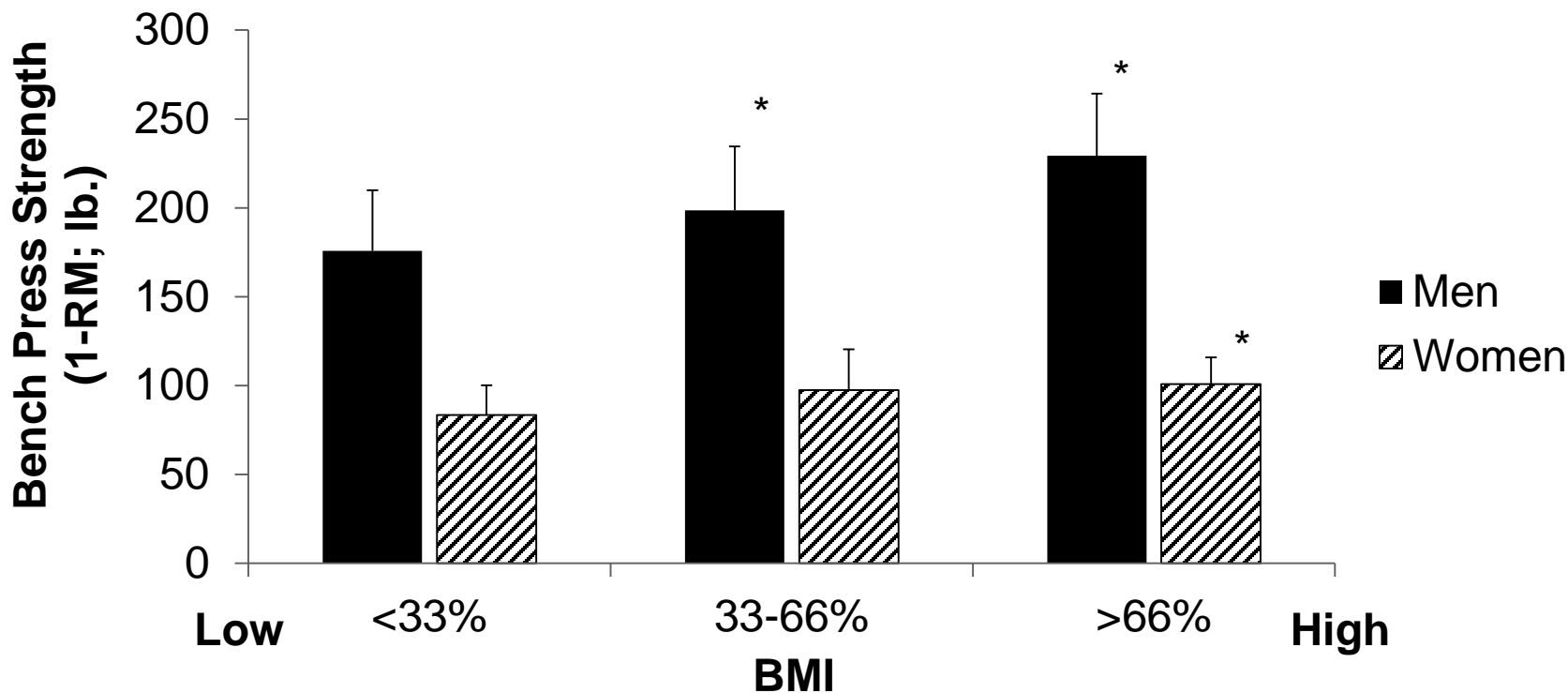


	ANOVA		
<b>Men (kg/m<sup>2</sup>)</b> n=275	18.6 - 23.8 n=91	23.9 - 26.5 n=90	26.6 - 34.9 n=94
<b>Women (kg/m<sup>2</sup>)</b> n=46	16.9 - 22.1 n=15	22.1 - 25.4 n=16	25.6 - 28.6 n=15
			.000
			.708

Data are mean ± SD; \*P<0.05 vs. tertile 1 (T1) (<33%)

Source: Pierce J et al., JSAMS, 2017

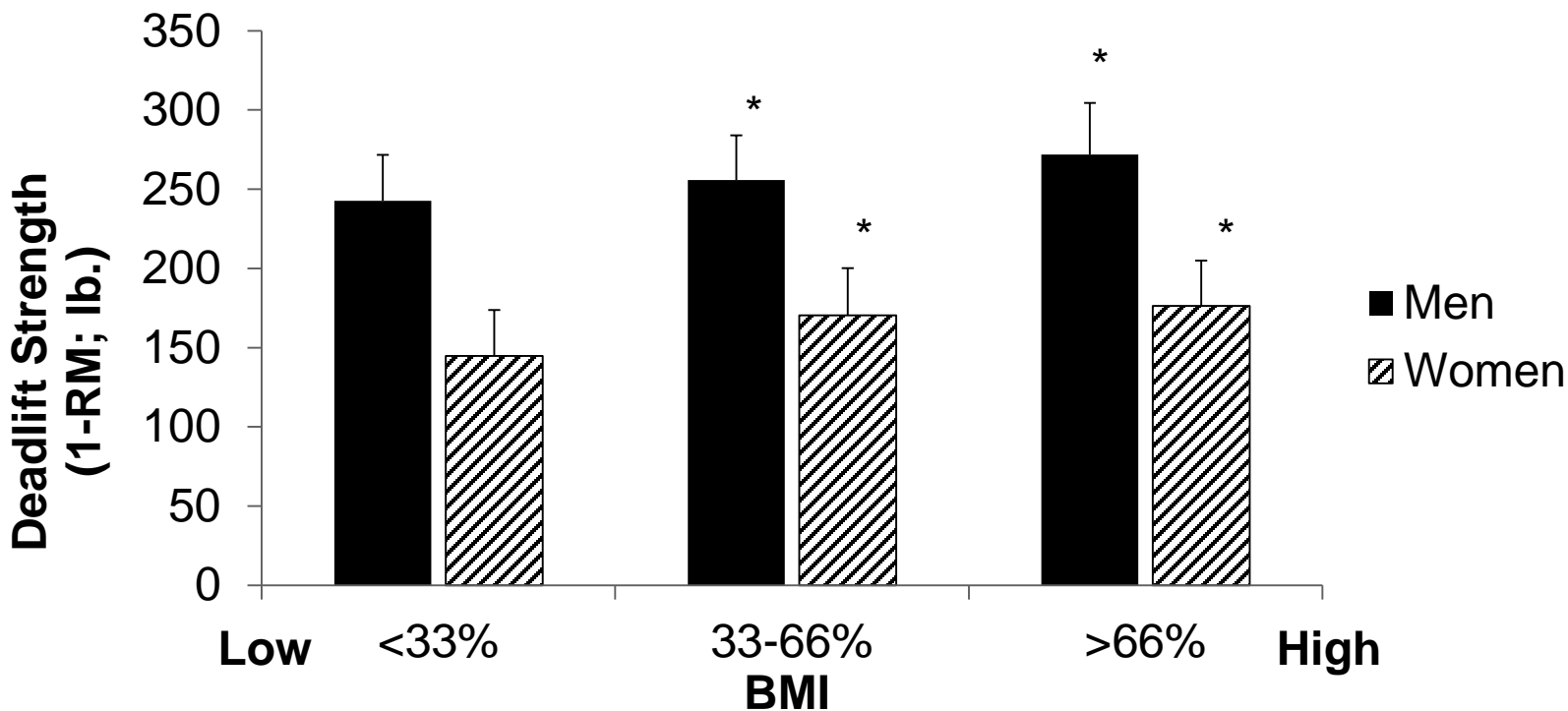
**As BMI increases, upper body muscle strength increases for men and women**



	Low (<33%)	33-66%	High (>66%)	ANOVA
<b>Men (kg/m<sup>2</sup>)</b>	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9	.000
<b>n=275</b>	n=91	n=90	n=94	
<b>Women (kg/m<sup>2</sup>)</b>	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6	.035
<b>n=46</b>	n=15	n=16	n=15	

Data are mean ± SD; \*P≤0.05 vs. tertile 1 (T1) (<33%); 1-Repetition Maximum (1-RM) in pounds (lbs) Source: Pierce J et al., JSAMS, 2017

**As BMI increases, lower body strength increases for men and women**



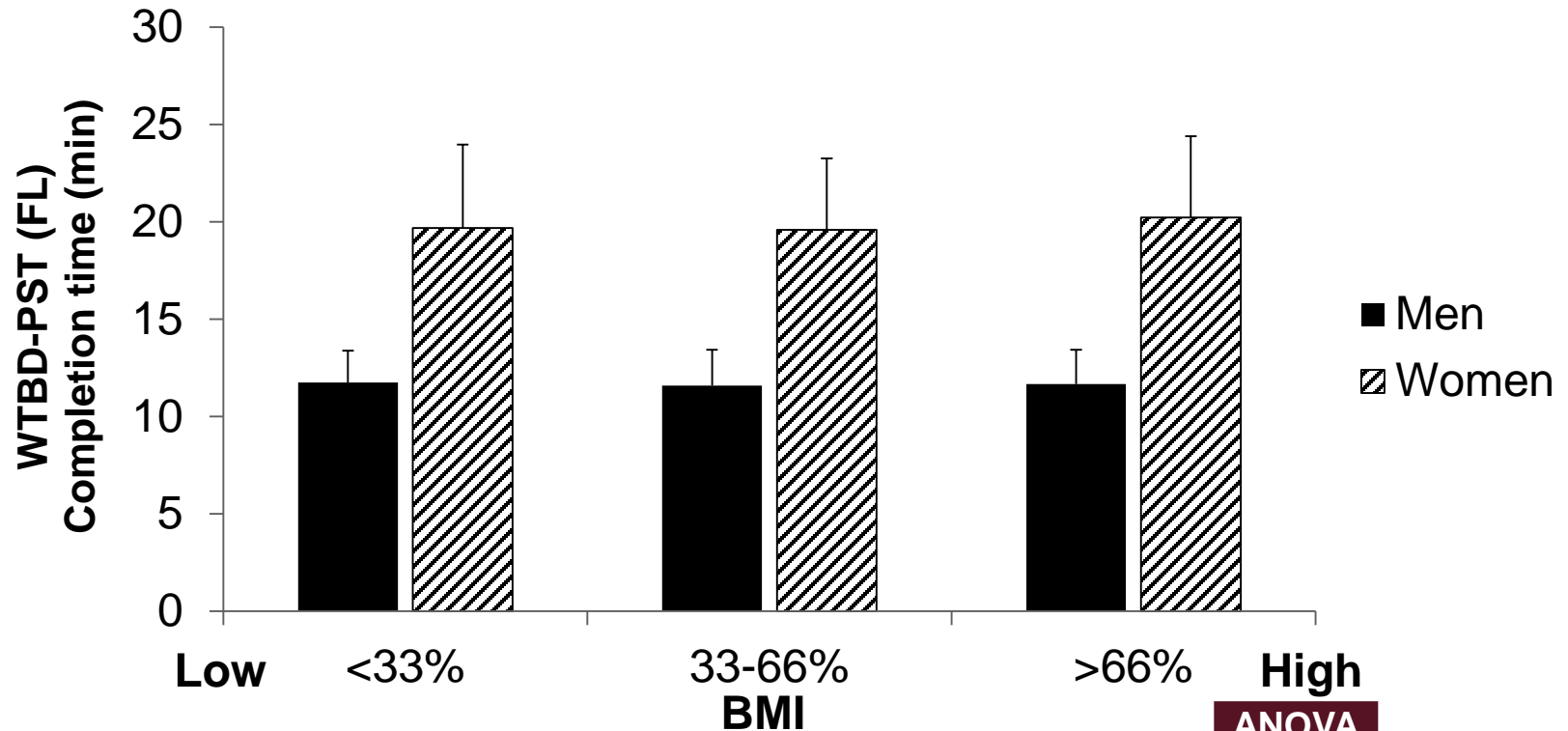
	ANOVA		
<b>Men (kg/m<sup>2</sup>)</b> n=275	18.6 - 23.8 n=91	23.9 - 26.5 n=90	26.6 - 34.9 n=94
<b>Women (kg/m<sup>2</sup>)</b> n=46	16.9 - 22.1 n=15	22.1 - 25.4 n=16	25.6 - 28.6 n=15
			<b>.000</b>
			<b>.011</b>

Data are mean ± SD; \*P≤0.05 vs. tertile 1 (T1) (<33%); 1 Rep Max in pounds

Source: Pierce J et al., JSAMS, 2017

# BMI vs. Overall Combat Fitness (WTBD with Fighting Load)

**BMI makes no difference in performance of military tasks and obstacle course**

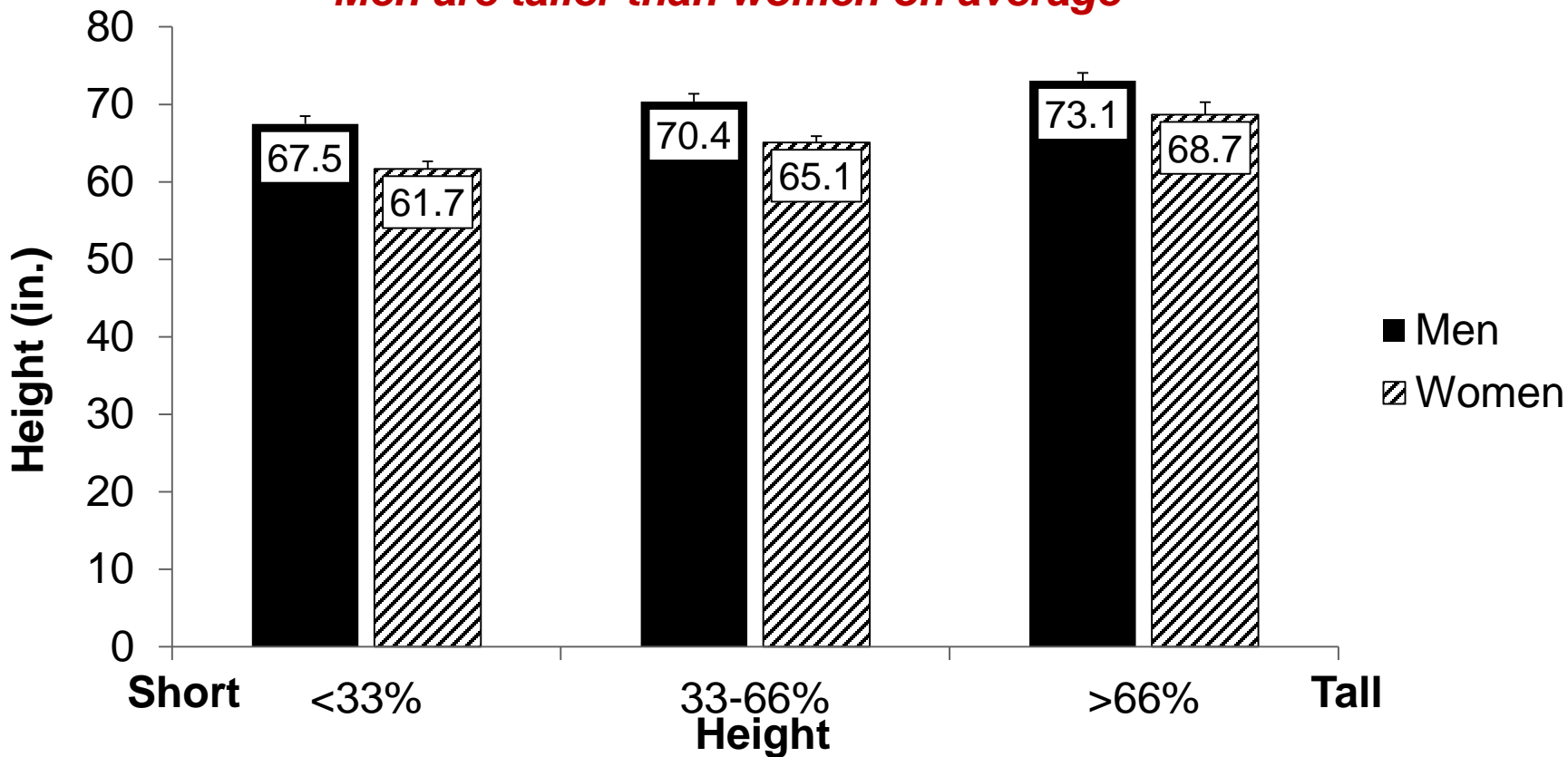


	BMI			ANOVA
<b>Men (kg/m<sup>2</sup>)</b> n=275	18.6 - 23.8 n=91	23.9 - 26.5 n=90	26.6 - 34.9 n=94	.817
<b>Women (kg/m<sup>2</sup>)</b> n=46	16.9 - 22.1 n=15	22.1 - 25.4 n=16	25.6 - 28.6 n=15	.897

Data are mean ± SD; No BMI effects noted for either men or women; four components of WTBD (Warrior Tasks and Battle Drills): (1) establish a fighting position, (2) move over, under, around, and through obstacles, (3) combatives simulation, and (4) casualty extraction and evacuation.

Source: Pierce J et al., JSAMS, 2017

*Men are taller than women on average*



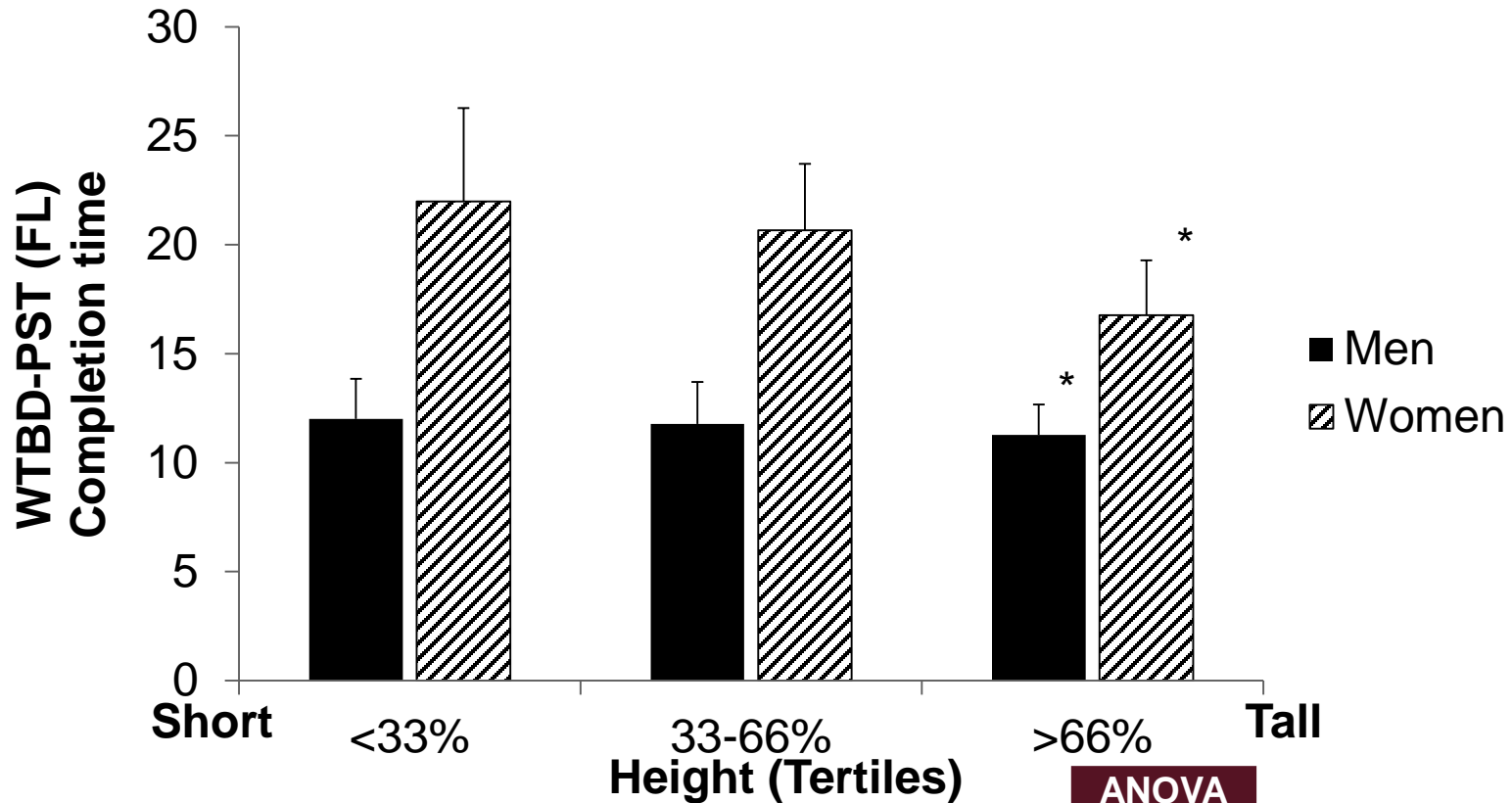
	<33%	33-66%	>66%
<b>Men (in.)</b>	<b>64-69</b>	<b>70-71</b>	<b>72-77</b>
<b>n=275</b>	<b>n=87</b>	<b>n=88</b>	<b>n=100</b>
<b>Women (in.)</b>	<b>60-63</b>	<b>64-66</b>	<b>67-72</b>
<b>n=46</b>	<b>n=15</b>	<b>n=16</b>	<b>n=15</b>

Source: Pierce J et al., JSAMS, 2017



# Height vs. Overall Combat Fitness (WTBD with Fighting Load)

**Tallest men and women complete military tasks (an obstacle course) more quickly**



	Height (Tertiles)			ANOVA
<b>Men (in.)</b>	<b>64-69</b>	<b>70-71</b>	<b>72-77</b>	<b>.011</b>
<b>n=275</b>	<b>n=87</b>	<b>n=88</b>	<b>n=100</b>	
<b>Women (in.)</b>	<b>60-63</b>	<b>64-66</b>	<b>67-72</b>	<b>.000</b>
<b>n=46</b>	<b>n=15</b>	<b>n=16</b>	<b>n=15</b>	

Data are mean ± SD; \*P≤0.05 vs. tertile 1 (T1) (<33%)

Source: Pierce J et al., JSAMS, 2017

- As BMI increases, aerobic fitness decreases for men and women
- As BMI increases, upper body muscle endurance increases for men
- As BMI increases, lower body muscle endurance increases for men and women
- As BMI increase, upper and lower body strength increase for men and women
- As BMI increases, there is no change in overall combat fitness (WTBD obstacle course time) for men or women
- As height increases, overall combat fitness improves (WTBD obstacle course times get faster) for men and women.

# Effects of Deployment on Body Composition & Physical Fitness



# Effect of Deployment on Body Composition & Physical Fitness of Soldiers



**Over the course of a 9-month deployment, male Soldiers gained weight and their BMI increased but muscle strength and endurance remained unchanged**

Variable	n	Pre-deployment	Post-deployment	P value
Height (in)	142	70 ± 3	70 ± 3	0.93
Body weight (lb)	142	176 ± 2.6	179 ± 2.6	< 0.01
BMI (kg/m <sup>2</sup> )	142	25.4 ± 3.3	25.9 ± 3.4	< 0.01
Push-ups (#)	178	64 ± 13	66 ± 13	0.15
Sit-ups (#)	178	68 ± 11	68 ± 11	0.26
2-mile run time (min)	178	14.7 ± 1.2	14.6 ± 1.6	0.61
APFT Score (0-300 points)	178	250 ± 38	250 ± 38	0.83

APFT Score: An age- & sex-adjusted metric; Sum of 3 scores (PU, SU, 2 mile run); min 60 points in each event to pass standards; 9-month deployment

Knapik, JJ et al. Injuries and Physical Fitness Before and After Deployment of the 10<sup>th</sup> Mountain Division to Afghanistan and the 1<sup>st</sup> Cavalry Division to Iraq, September 2005-October 2008; Report No. 12-HF-05SR-05, 2008.



# Effect of Deployment on Body Composition & Physical Fitness of Soldiers



**Body weight & percent body fat increased as well as strength and power**

Variable	n	Pre-deployment	Post-deployment	Δ (%) <sup>a</sup>
Height (cm)	73	174 ± 7	174 ± 7	--
Body weight (kg)	73	76.6 ± 10.2	78.8 ± 10.6	↑ 2.9*
Lean mass (kg)	73	58.3 ± 5.8	60.1 ± 6.2	↑ 3.0*
BMI (kg/m <sup>2</sup> )	73	25.3	26.0	
Body fat (kg)	73	13.4 ± 5.3	14.5 ± 5.6	↑ 8.7*
Body fat (%)	73	18.9 ± 5.5	19.9 ± 5.6	↑ 4.2*
Strength (1-RM, kg)				
Bench press	68	79.1 ± 17.4	84.9 ± 20.9	↑ 7.4*
Back squat	65	99.7 ± 20.9	107.8 ± 23.4	↑ 8.1*
Power (W)				
Bench throw	67	526.3 ± 137.1	572.3 ± 143.2	↑ 8.7*
Squat jump	63	1856.3 ± 272.9	1856.8 ± 333.2	↔ 0.3

\*Statistically significant increase p< 0.01) compared to pre-deployment based on paired t-test.

<sup>a</sup>(post-pre)/pre X 100; 13-month deployment

Lester, ME et al –Effect of deployment on performance, Mil Med, 2010

- Post-deployment BMI and percent body fat appear to increase among male Soldiers.
- Post-deployment muscle strength and muscle endurance appear to increase or remain the same among male Soldiers.

- What are the correlations of BMI with physical fitness and injury risk among Soldiers?
- What is the correlation of BMI with components of physical fitness and military task performance?
- What is the effect of deployment to areas of combat on body composition and physical fitness?
- What can we conclude from the data?

- What are the correlations of BMI with physical fitness and injury risk among Soldiers?
  - Highest injury risks are among men and women with the lowest BMIs and slowest run times



- What is the correlation of BMI with components of physical fitness and military task performance?
  - High BMI is correlated with lower aerobic fitness, but higher muscle endurance and strength.
  - Taller height is associated with better performance of military tasks

- What is the effect of deployment on body composition and physical fitness?
  - Post-deployment % body fat and BMI appear to increase.
  - Post-deployment muscle strength and muscle endurance appear to increase or stay the same.

- What can we conclude from the data?
  - Stating that increased BMI is associated with decreased readiness may be misleading, since Soldiers with higher BMI and higher fitness have shown greater musculoskeletal resilience (less injury prone).
  - If the Army desires the most physically ready Soldiers they may need standards that take into consideration both physical fitness and body composition/fat.