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

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Disclaimer

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Purpose

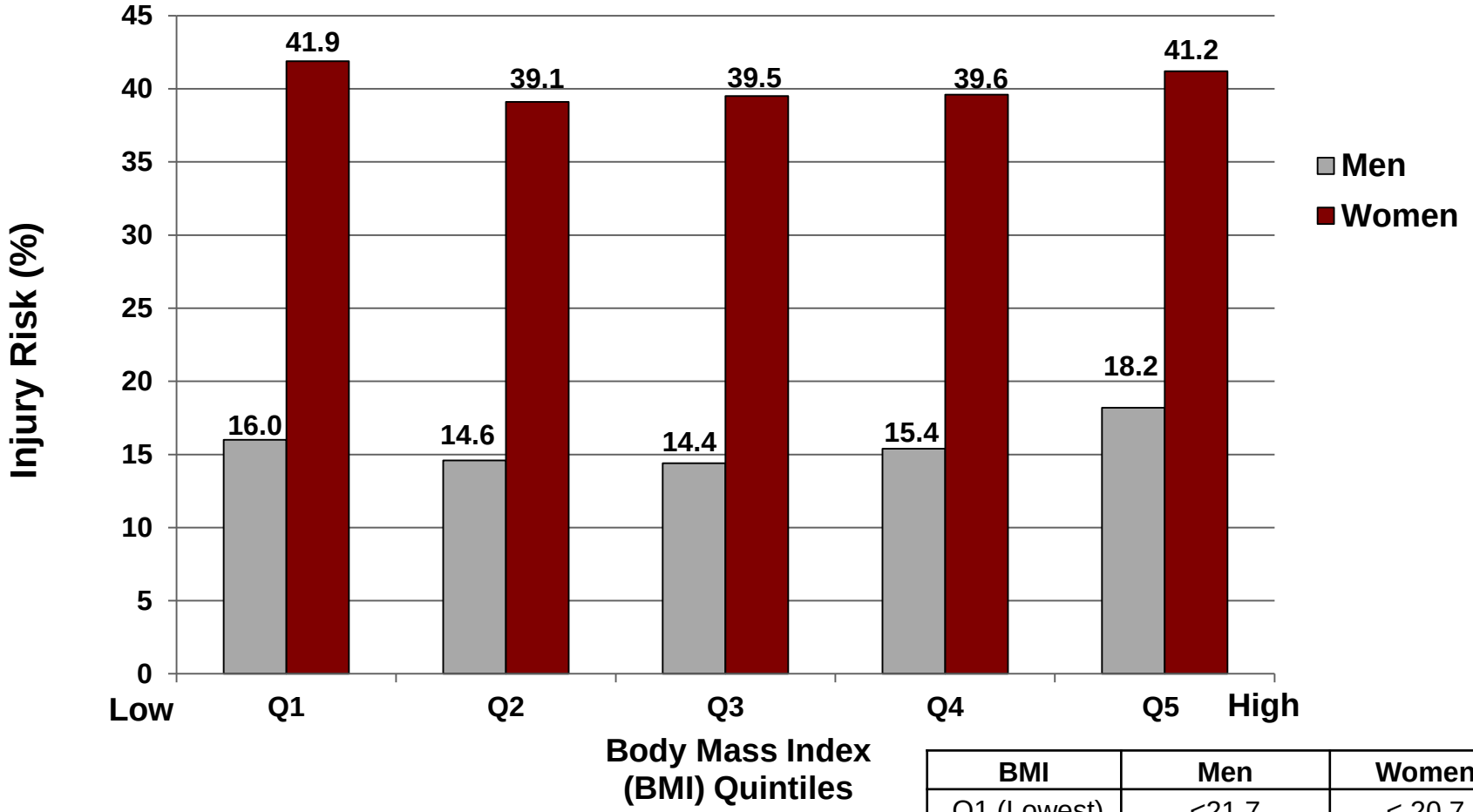
- Use recent Army data to illustrate the complexity of the relationship of BMI, % body fat, physical fitness, and injury risks.
- Examine the effects of deployment to combat zones on body composition and physical fitness.

Guiding Questions

- 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

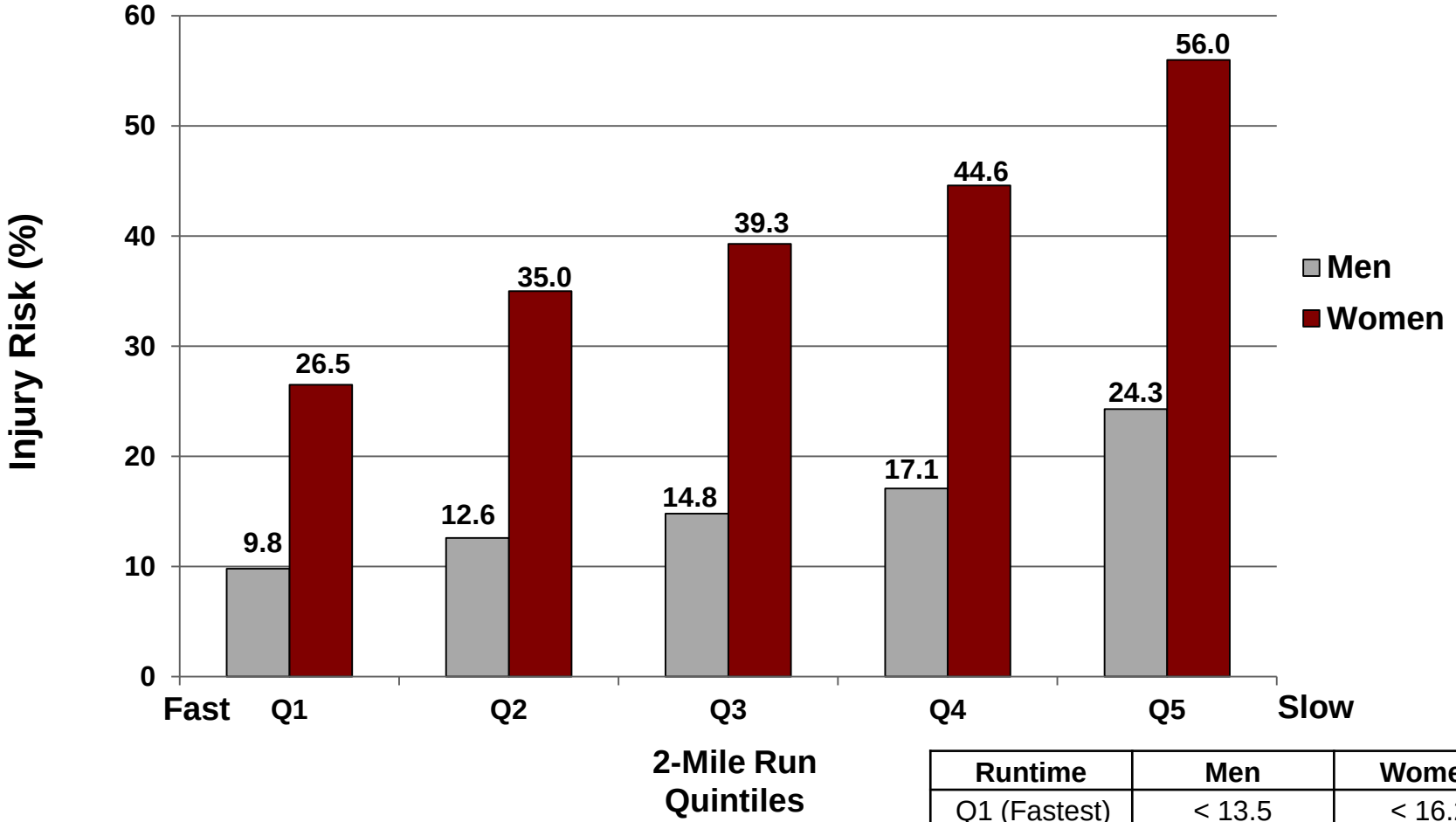
Body Mass Index (BMI) and Injury Risk (%) for Men and Women in BCT



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

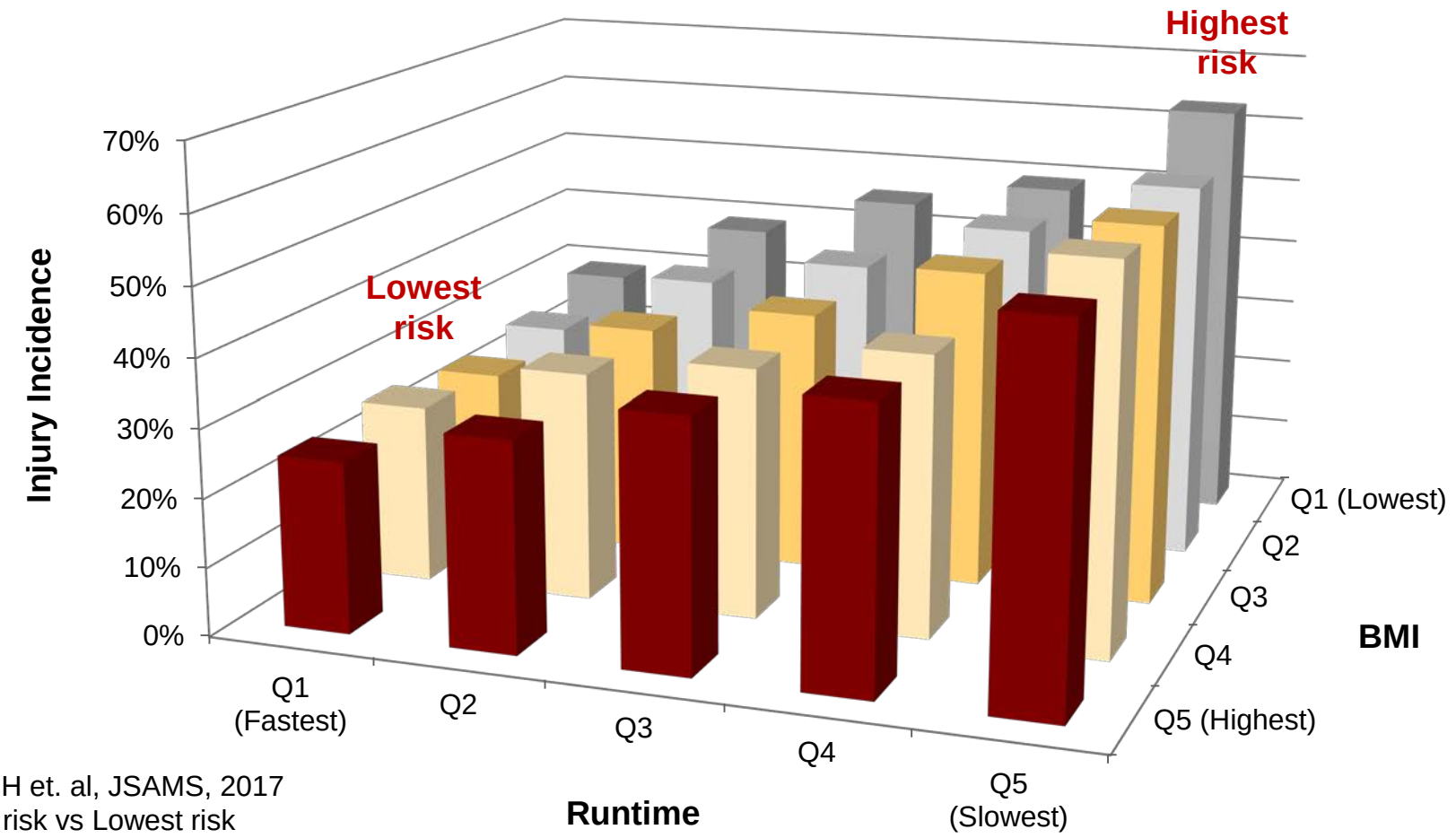


Runtime	Men	Women
Q1 (Fastest)	< 13.5	< 16.2
Q2	13.5 – 14.2	16.2 – 17.3
Q3	14.3 – 15.0	17.4 – 18.1
Q4	15.1 – 15.8	18.2 – 19.0
Q5 (Slowest)	>15.8	>19.0

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)

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

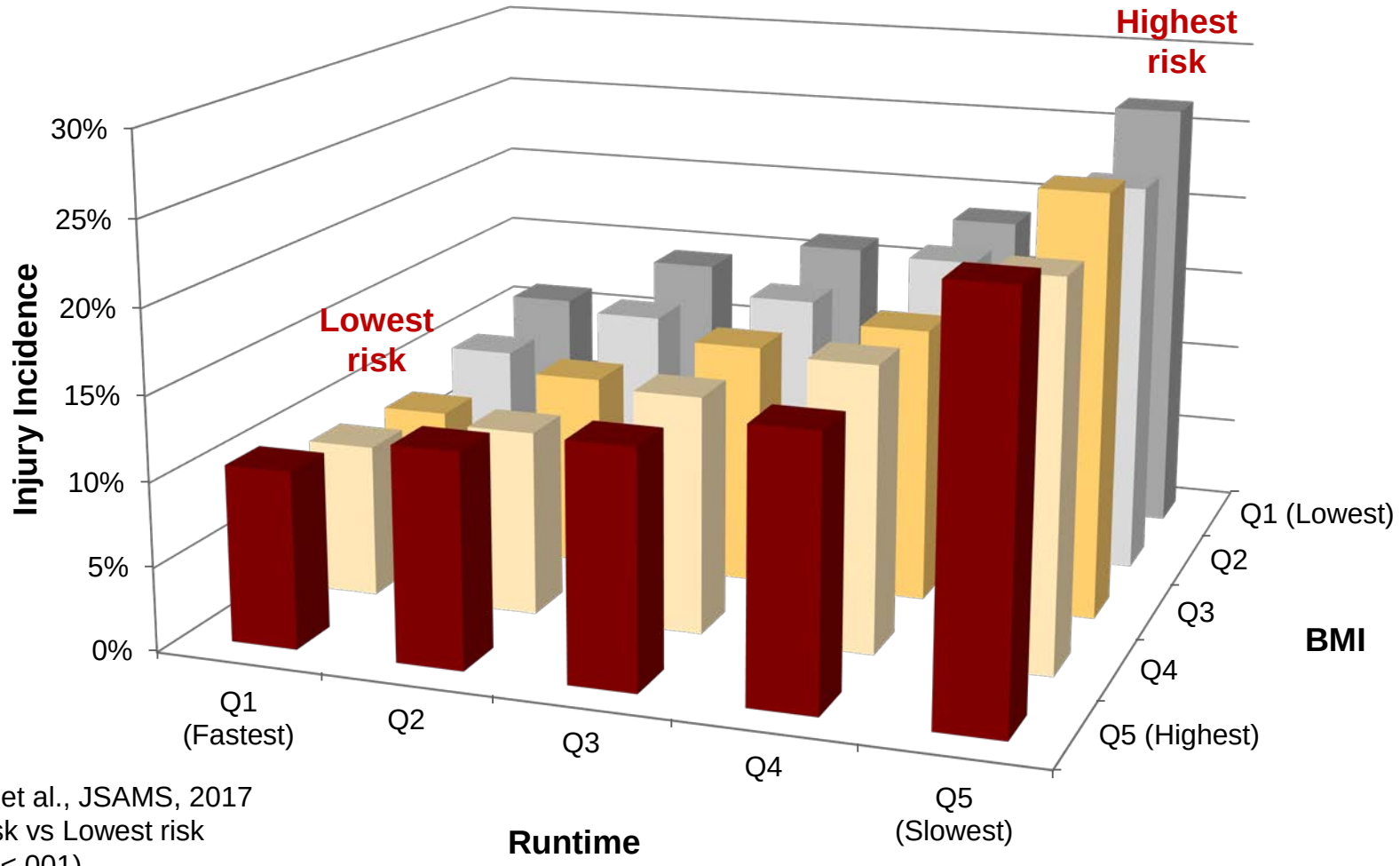
Lowest risks are the most aerobically fit, middle to high BMI quintiles
Highest risks are the lowest BMIs across all fitness levels



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)

Summary

- 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

Age	Average BMI[a] ± SD (n)	Average 2-Mile Run Time[b] ± SD (n)
≤ 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)

[a] N = 1,191

[b] 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

2-Mile Run Time	Average BMI ± SD (n)
≤ 13.92 minutes	24.5 ± 2.9 (218)
13.93-14.92 minutes	25.3 ± 3.3 (211)
14.93-15.90 minutes	26.6 ± 3.5 (214)
15.91 + minutes	27.9 ± 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^2 (+/- 3.9)

Source: Rappole et al., JSAMS, 2017

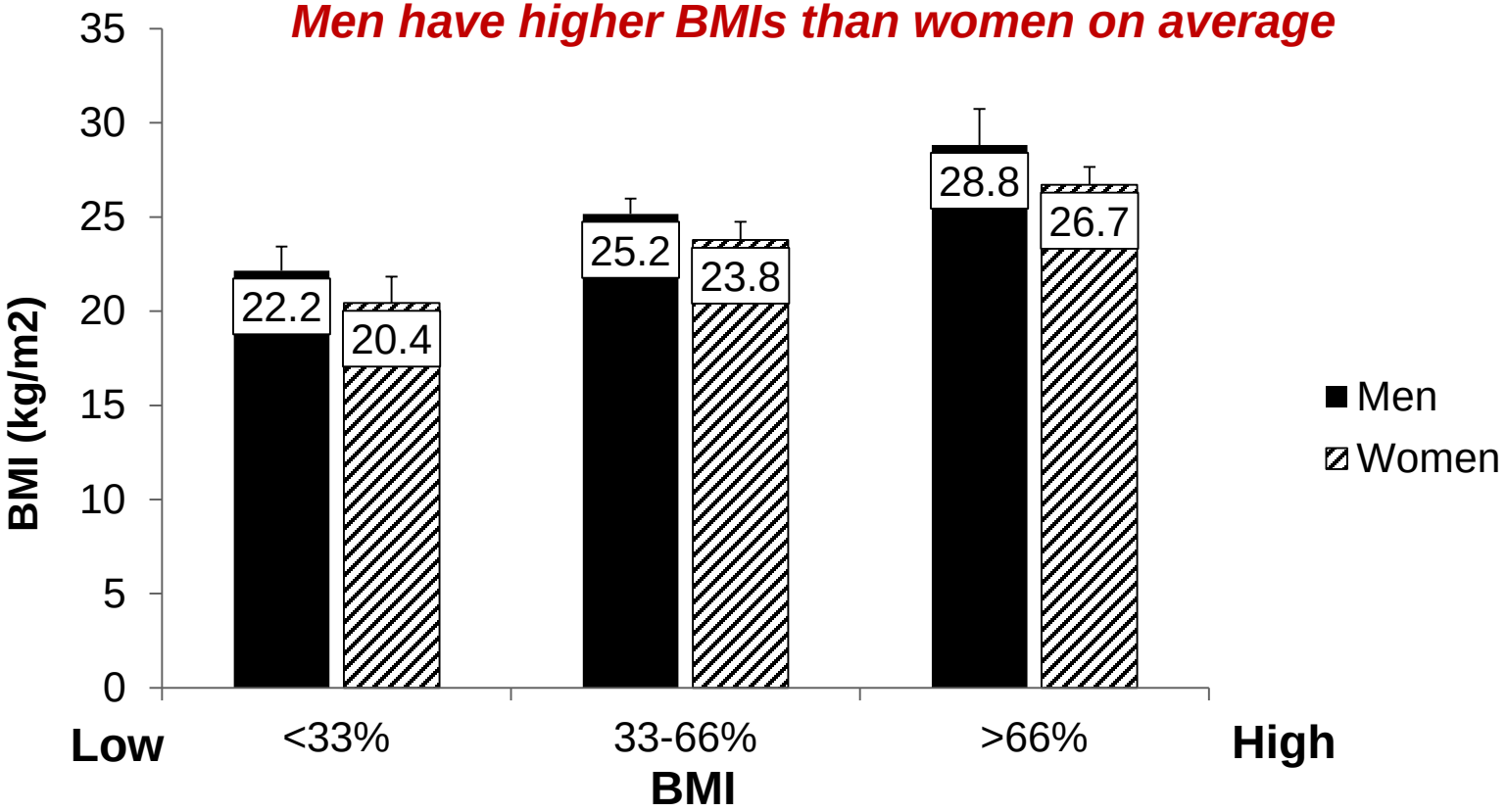
Summary

- 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

BMI Tertiles by Sex

Men have higher BMIs than women on average

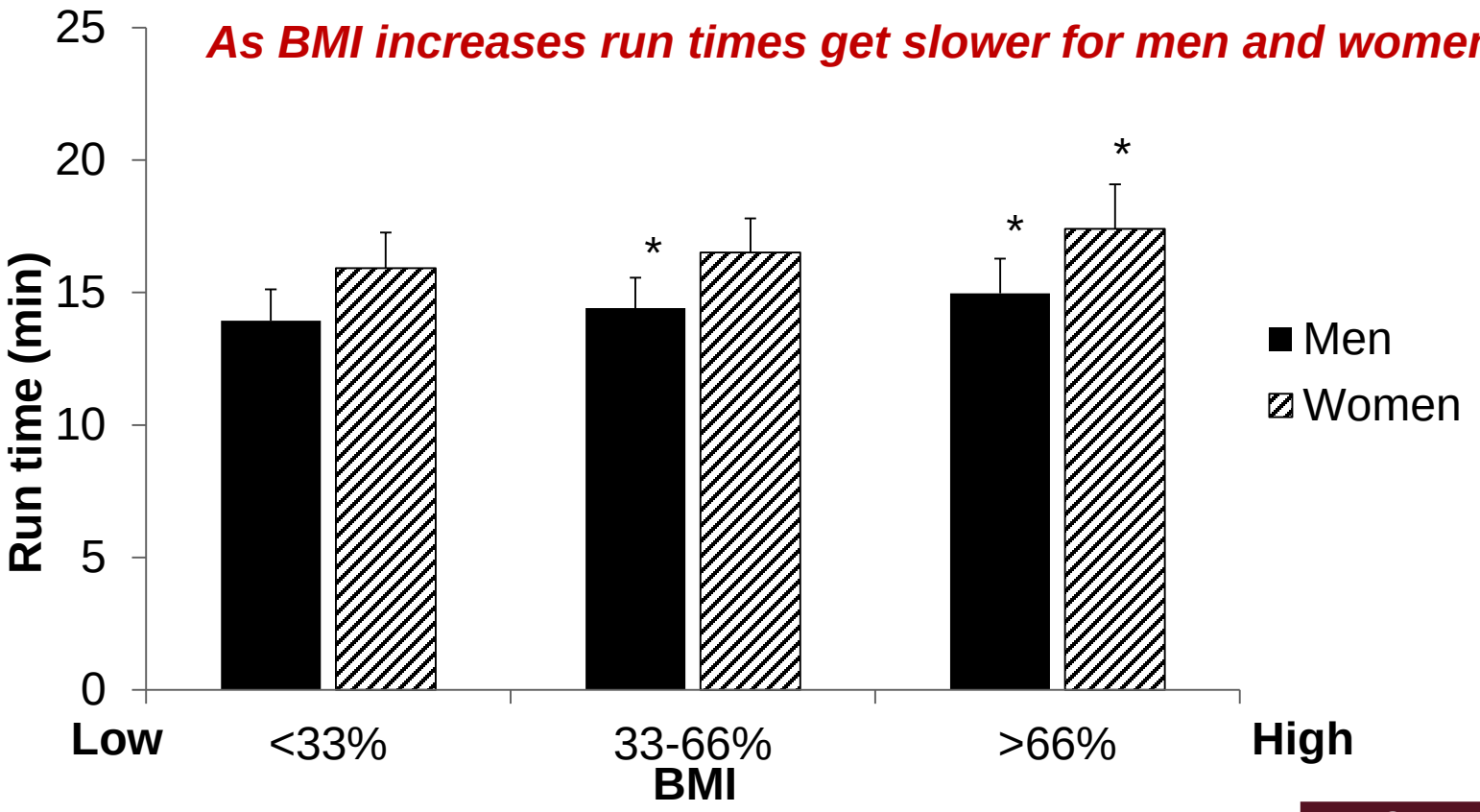


	<33%	33-66%	>66%
Men (kg/m^2)	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9
n=275	n=91	n=90	n=94
Women (kg/m^2)	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6
n=46	n=15	n=16	n=15

Source: Pierce J et al., JSAMS, 2017

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

As BMI increases run times get slower for men and women



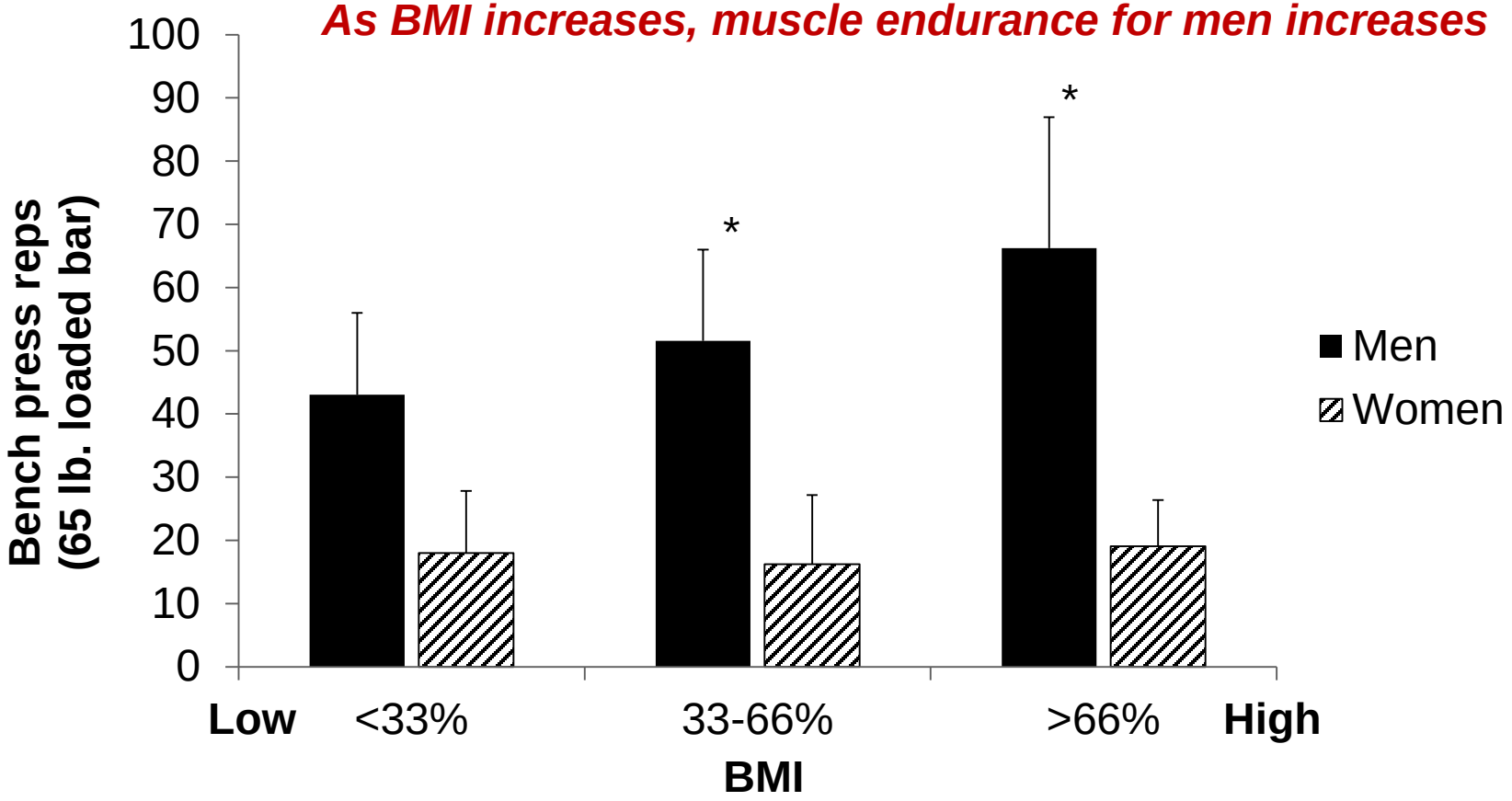
				ANOVA
Men (kg/m²)	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9	.000
n=275	n=91	n=90	n=94	
Women (kg/m²)	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6	.025
n=46	n=15	n=16	n=15	

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

Source: Pierce J et a., JSAMS, 2017

BMI vs. Muscular Endurance (Upper Body)

As BMI increases, muscle endurance for men increases



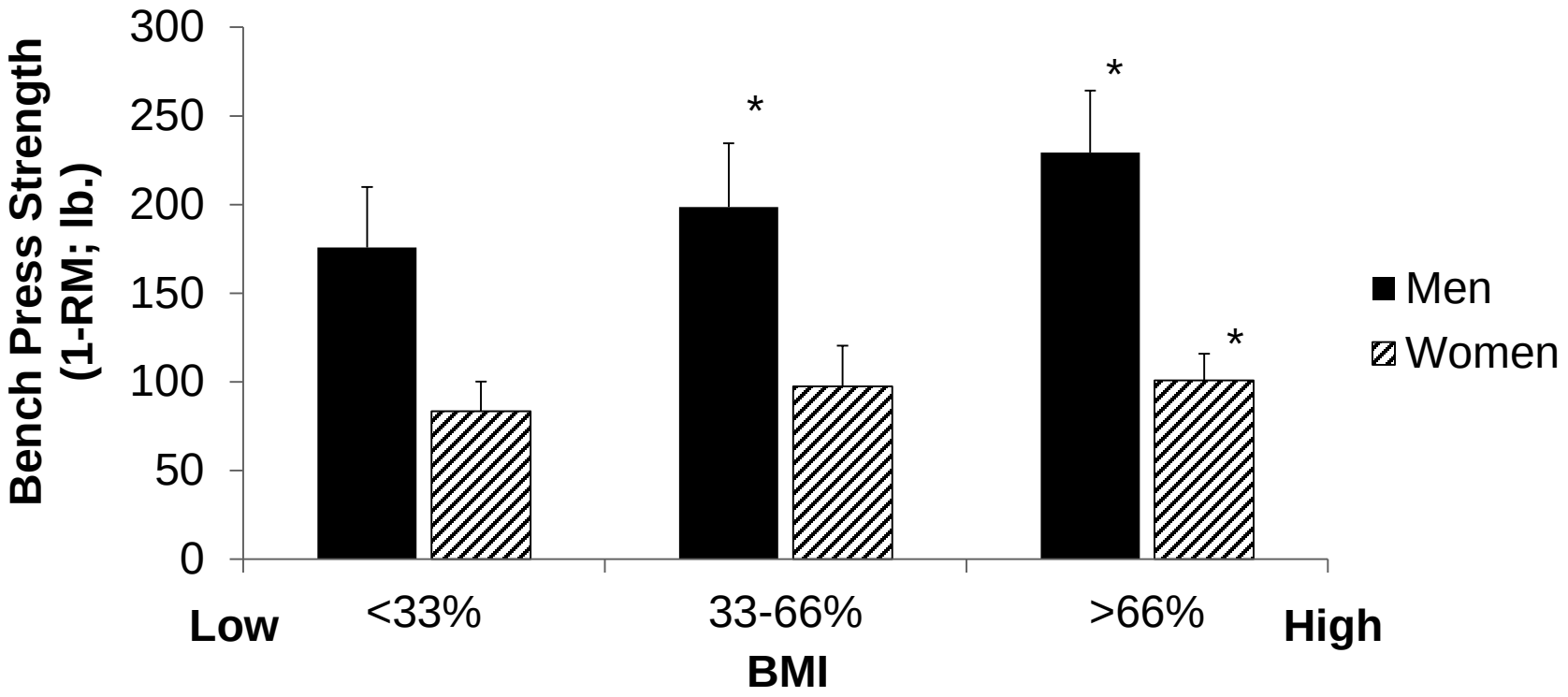
				ANOVA
Men (kg/m^2)	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9	.000
n=275	n=91	n=90	n=94	
Women (kg/m^2)	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6	.708
n=46	n=15	n=16	n=15	

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

Source: Pierce J et al., JSAMS, 2017

BMI vs. Muscular Strength (Upper Body)

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

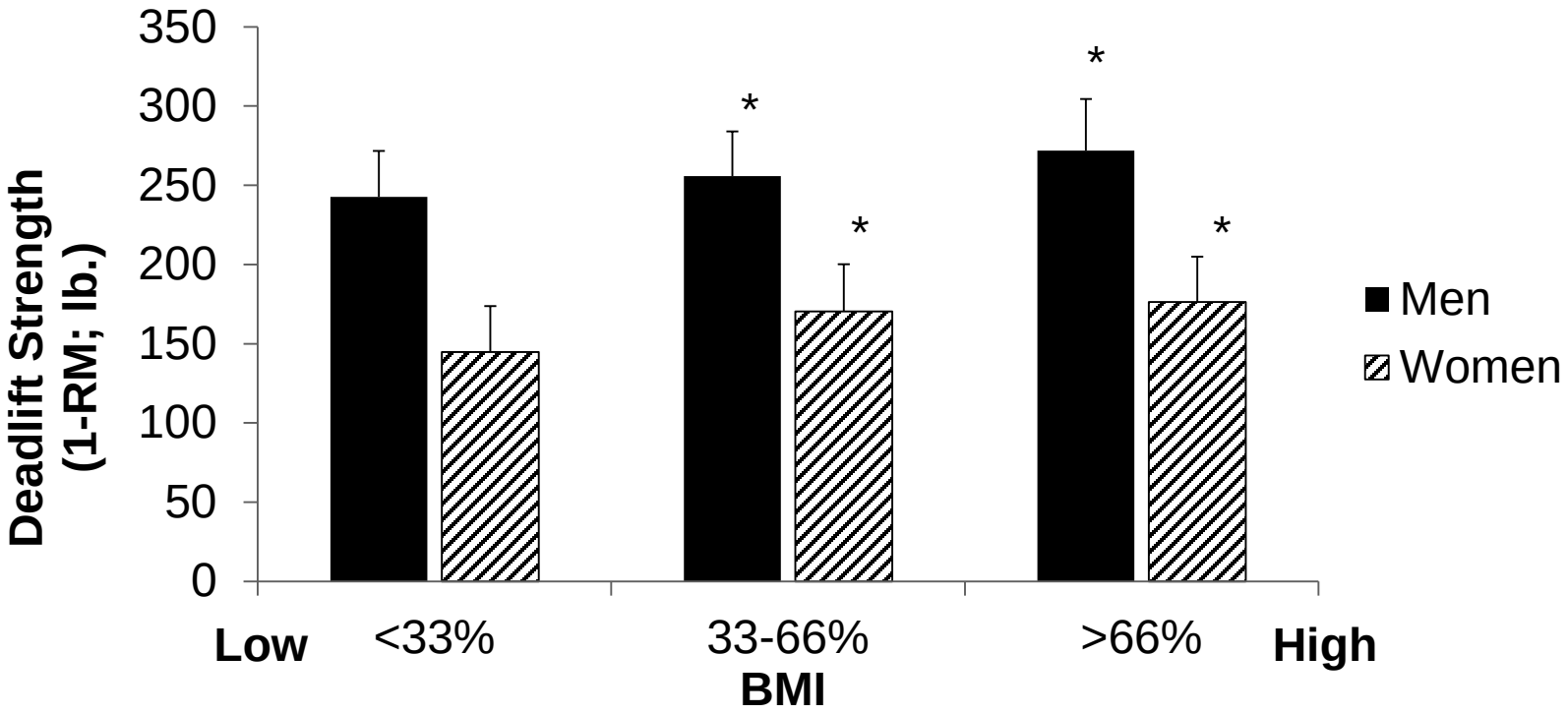


Men (kg/m²)	**18.6 - 23.8**	**23.9 - 26.5**	**26.6 - 34.9**	**ANOVA**
n=275	**n=91**	**n=90**	**n=94**	**.000**
Women (kg/m²)	**16.9 - 22.1**	**22.1 - 25.4**	**25.6 - 28.6**	**.035**
n=46	**n=15**	**n=16**	**n=15**	

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

BMI vs. Muscular Strength (Lower Body)

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



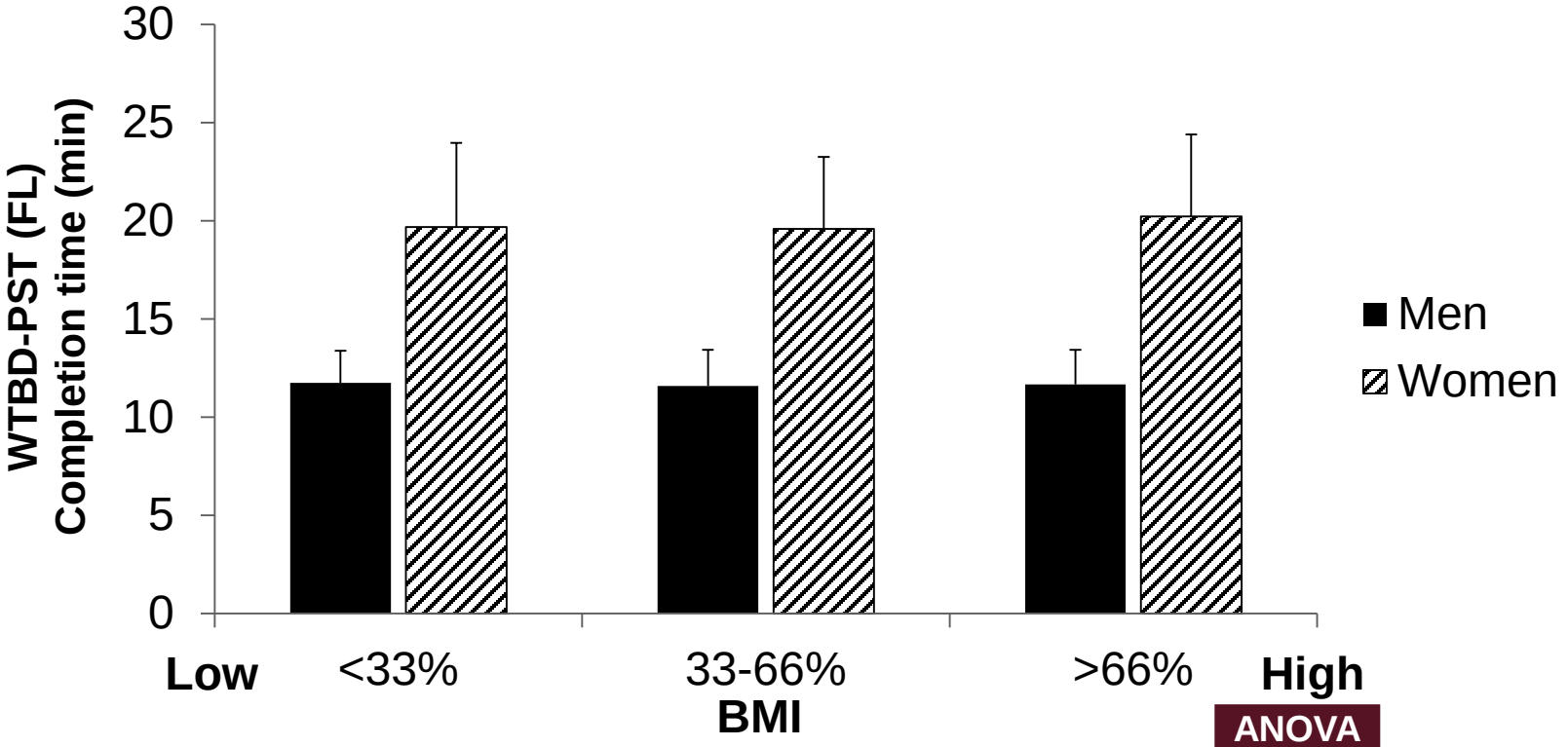
				ANOVA
Men (kg/m²)	18.6 - 23.8	23.9 - 26.5	26.6 - 34.9	.000
n=275	n=91	n=90	n=94	
Women (kg/m²)	16.9 - 22.1	22.1 - 25.4	25.6 - 28.6	.011
n=46	n=15	n=16	n=15	

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



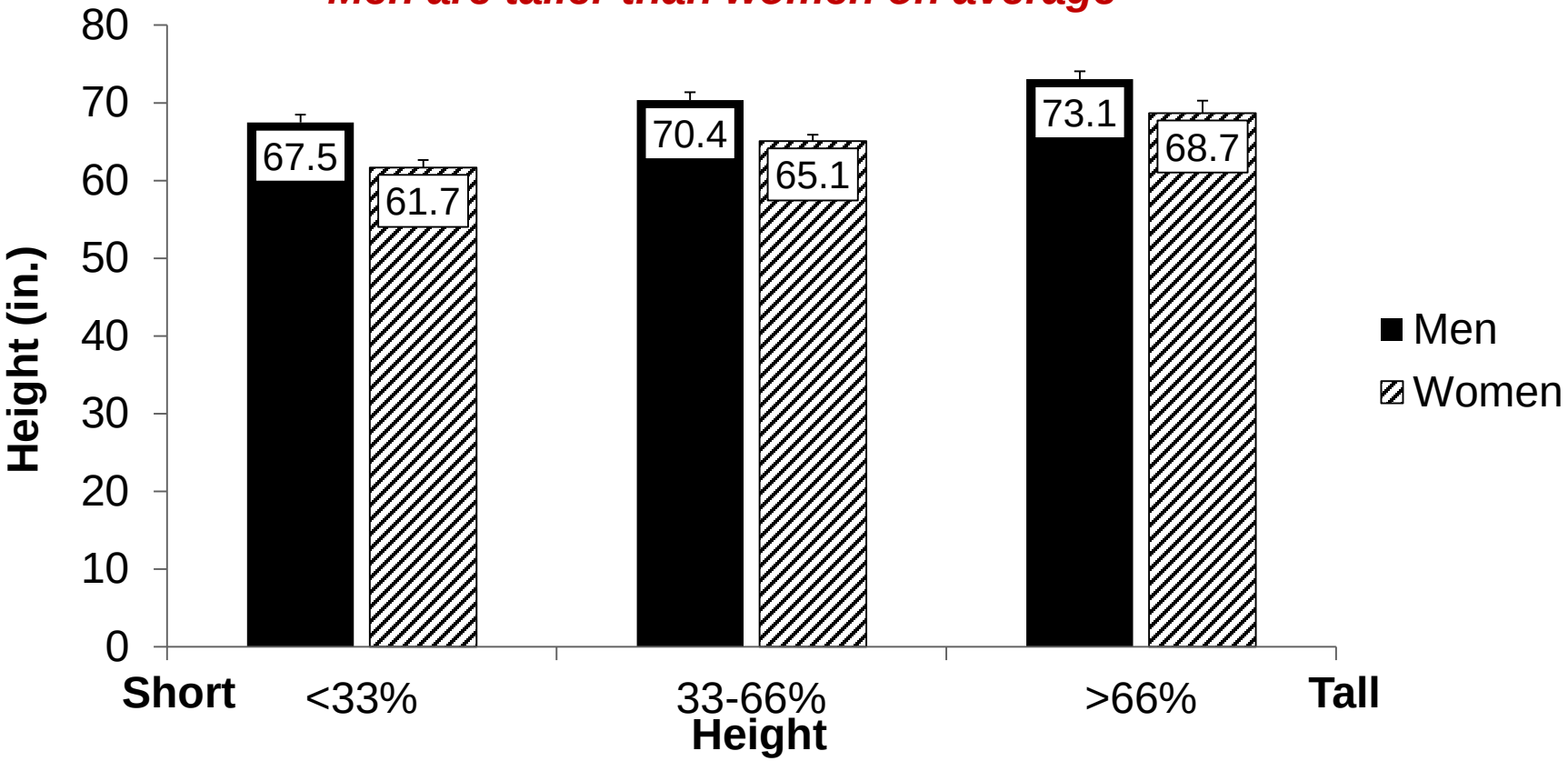
	Low	<33%	33-66%	>66%	High	ANOVA
Men (kg/m²)	18.6 - 23.8		23.9 - 26.5		26.6 - 34.9	.817
n=275	n=91		n=90		n=94	
Women (kg/m²)	16.9 - 22.1		22.1 - 25.4		25.6 - 28.6	.897
n=46	n=15		n=16		n=15	

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

Height Tertiles by Sex

Men are taller than women on average

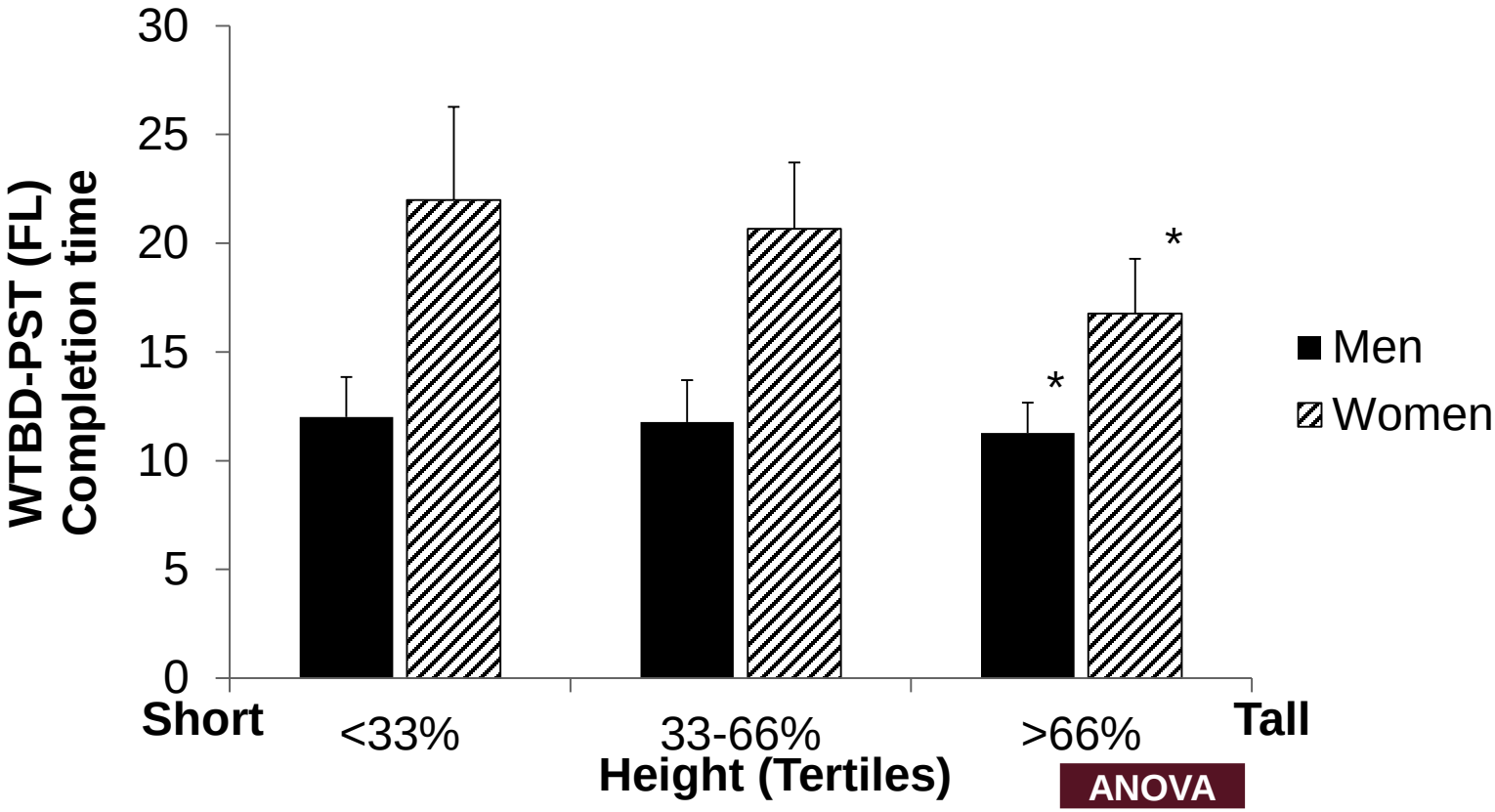


	<33%	33-66%	>66%
Men (in.)	64-69	70-71	72-77
n=275	n=87	n=88	n=100
Women (in.)	60-63	64-66	67-72
n=46	n=15	n=16	n=15

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



				ANOVA
Men (in.)	64-69	70-71	72-77	.011
n=275	n=87	n=88	n=100	
Women (in.)	60-63	64-66	67-72	.000
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

Summary

- 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^2)	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 10th Mountain Division to Afghanistan and the 1st Cavalry Division to Iraq, September 2005-Octoer 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 (%) [a]
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^2)	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.

[a](post-pre)/pre X 100; 13-month deployment

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

Summary

- 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.

Guiding Questions

- 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?

Questions and Answers

- 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

Questions and Answers

- 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

Questions and Answers

- 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.

Questions and Answers

- 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.