Physical Activity and Risks of Injuries in Civilian and Military Populations

The Soldier Medical Readiness Campaign IP/HPO Education Series

UNITED STATES ARMY PUBLIC HEALTH COMMAND

INJURY PREVENTION PROGRAM

22 MARCH 2012

Overview of PA-Related Injury Presentation

- Background
- Incidence of PA-related injuries
- Factors affecting risks of injuries
- Summary of Key Conclusions about Causes, Risk Factors and Prevention

Overview of PA-Related Injury Presentation

- Background
  - 1984 CDC Workshop on public health aspects of PA identified injuries as a risk about which little was known (Koplan JP et al. Pub Health Reports 100: 189-195,1985)
  - Much progress since 1984 primarily from studies of runners, walkers and military trainees

Knowledge Necessary to Prevent Physical Activity-Related Injuries

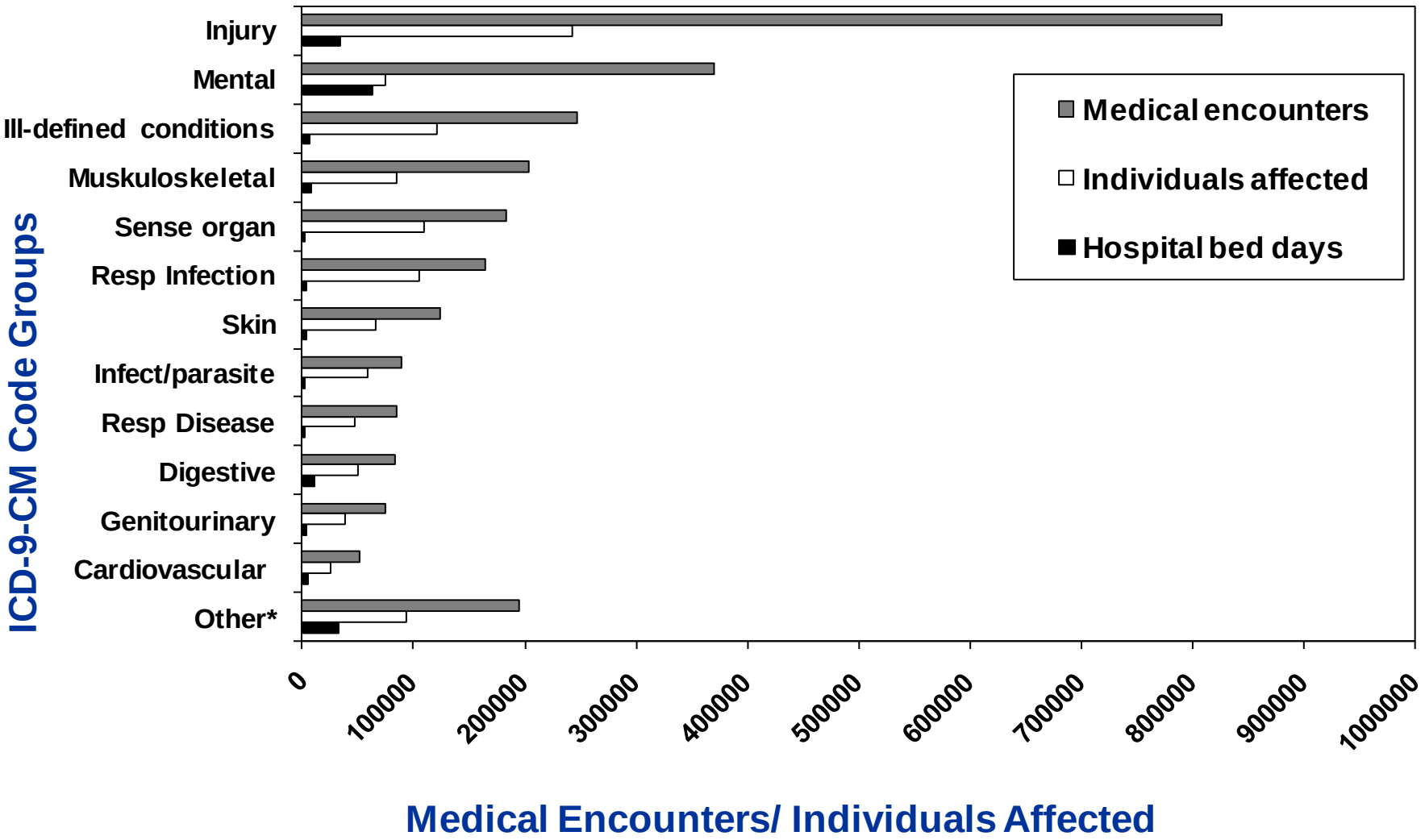
- How big is the problem?
- What causes the problem?
- Do modifiable risk factors for the problem exist?
- What works to prevent the problem?

To Answer Questions: *Focus on best studied PA-related injury problem, weight-bearing PA:*

  - ***Running, walking, etc.***
  - ***Military and civilian studies***

Magnitude of the Problem

Relative Burden of Injuries and Diseases, U.S. Army Active Duty, 2008



Source: Defense Medical Surveillance System, Armed Forces Health Surveillance Center, 2009

Distribution of Any Injury and Sports, Exercise, and Recreational Activities (SERA) Injury by Military Service

Service	Any Injury (≥1)	SERA Injury (≥1)
	Percent Injured	Percent Injured
Army	56.6	29.0
Navy	41.4	19.9
Marine Corps	53.0	32.6
Air Force	42.7	21.8
All Services	48.9	25.4

Source: USAPHC Technical Report No. 12-HF-0DPT-08

Participation in Sports, Exercise, Recreational Activities Related to Most Serious Injury in Past 12 Months

Sports, Exercise or Recreational Activity	Army	Navy	Marine Corps	Air Force	Total
	N=125,684	N=57,502	N=51,745	N=63,390	N=298,320
	Percent	Percent	Percent	Percent	Percent
Running or jogging (outdoors)	50.3	33.2	50.6	41.3	45.1
Weight training	6.4	8.9	6.6	9.6	7.6
Basketball	7.3	10.1	3.5	8.6	7.5
Touch or flag football	4.8	6.0	4.4	5.6	5.1
Martial arts	4.5	3.0	9.1	1.1	4.3
Softball or baseball	1.5	6.3	1.3	5.9	3.3
Soccer	2.0	3.6	5.4	3.6	3.2
Other	23.2	28.9	19.2	24.4	23.9

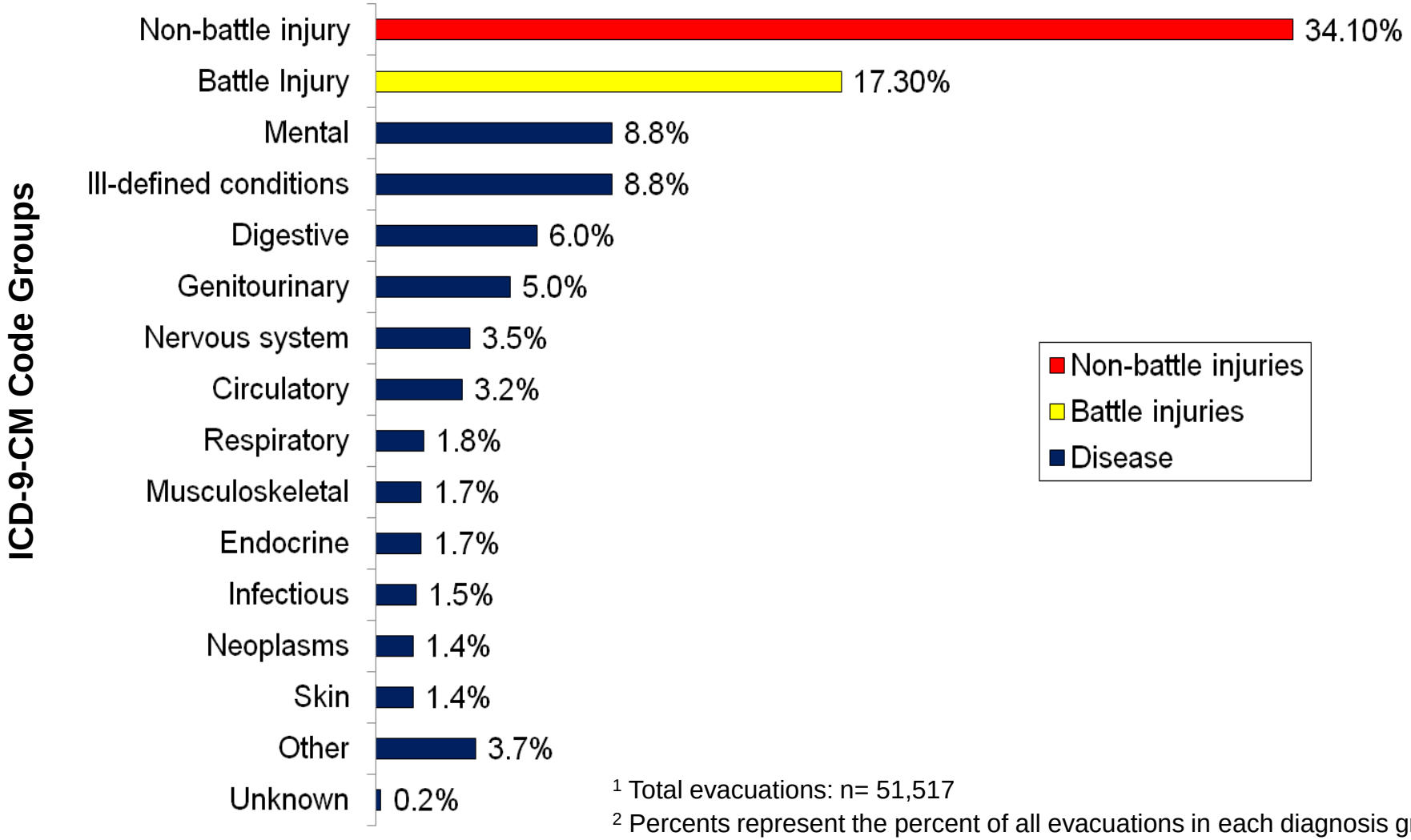
Source: USAPHC Technical Report No. 12-HF-0DPT-08

Days of Limited Duty by Service Injuries from Sports, Exercise, and Recreational Activity

Days of Limited Duty	Army	Navy	Marine Corps	Air Force	Total
	Percent Injured	Percent Injured	Percent Injured	Percent Injured	Percent Injured
0 Days	5.7	7.9	2.7	8.0	6.1
1 Day	22.0	31.8	17.6	35.6	26.0
2 to 7 Days	16.5	17.2	12.7	21.1	17.0
8 to 14 Days	17.2	13.1	23.5	10.9	16.2
≥ 15 Days	38.6	30.0	43.5	24.5	34.8
Total	100.0	100.0	100.0	100.0	100.0

Source: USAPHC Technical Report No. 12-HF-0DPT-08

Army OIF/OEF Medical Evacuations by Diagnosis Group: 2001 – 2009[1-3]

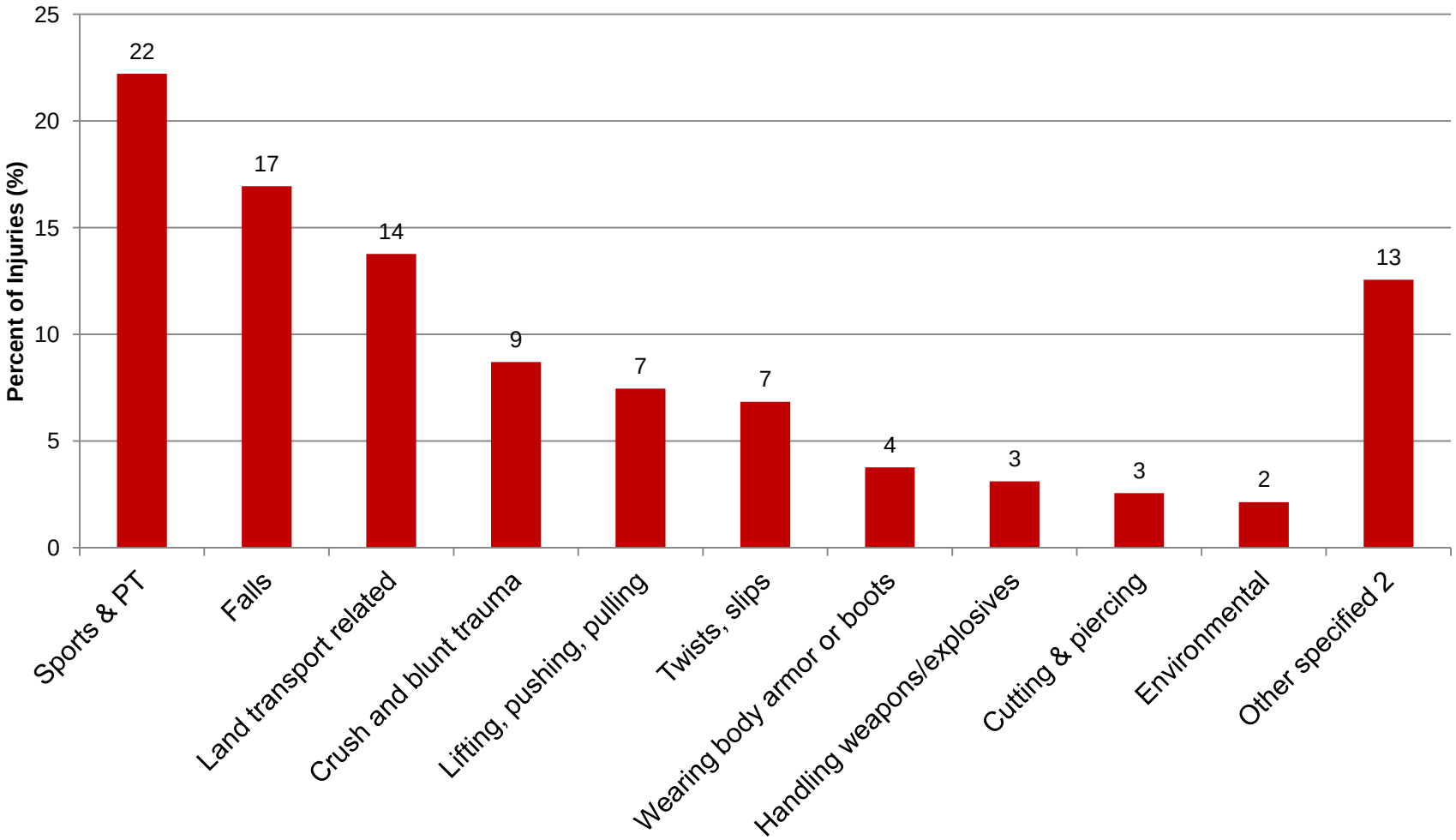


[1] Total evacuations: n= 51,517

[2] Percents represent the percent of all evacuations in each diagnosis group

[3] Operation Iraqi Freedom (OIF) started on 19 March 2003

Causes of Air Evacuated Non-battle Injuries, OIF/OEF, 2001-2009



Risks of Injuries Among Civilian Exercise Participants and Army Trainees

Activity	Gender/ Injury Source	Injury Risk (%) Time Period	Rate/100/yr
Running Rvw Jones BH 1994	Men & Women Recall 1 yr	25% - 65% 1 year	25-65/100p-yr
Walking Suter E 1994	Men & Women Recall q 3 mos	21% 6 months	42/100 p-yr
Bicycling Wilbur CA 1995	Men & Women Recall 1 yr	85% OU Inj/yr 25% Trauma/yr	85/100 p-yr 25/ 100 p-yr
Aerobic Dance Garrick JG 1986	Women & Men Wkly F/U	49% 6 weeks	160/100 p-yr
Exercise & Rec Sports Requa 93	Men & Women Wkly F/U	48% 12 weeks	208/100 p-yr
Army BCT Rvw Jones BH 1994	Men & Women Med Records	M 10%-15%/mo W 20%-30%/mo	120-180/100p-y 240-360/100p-y

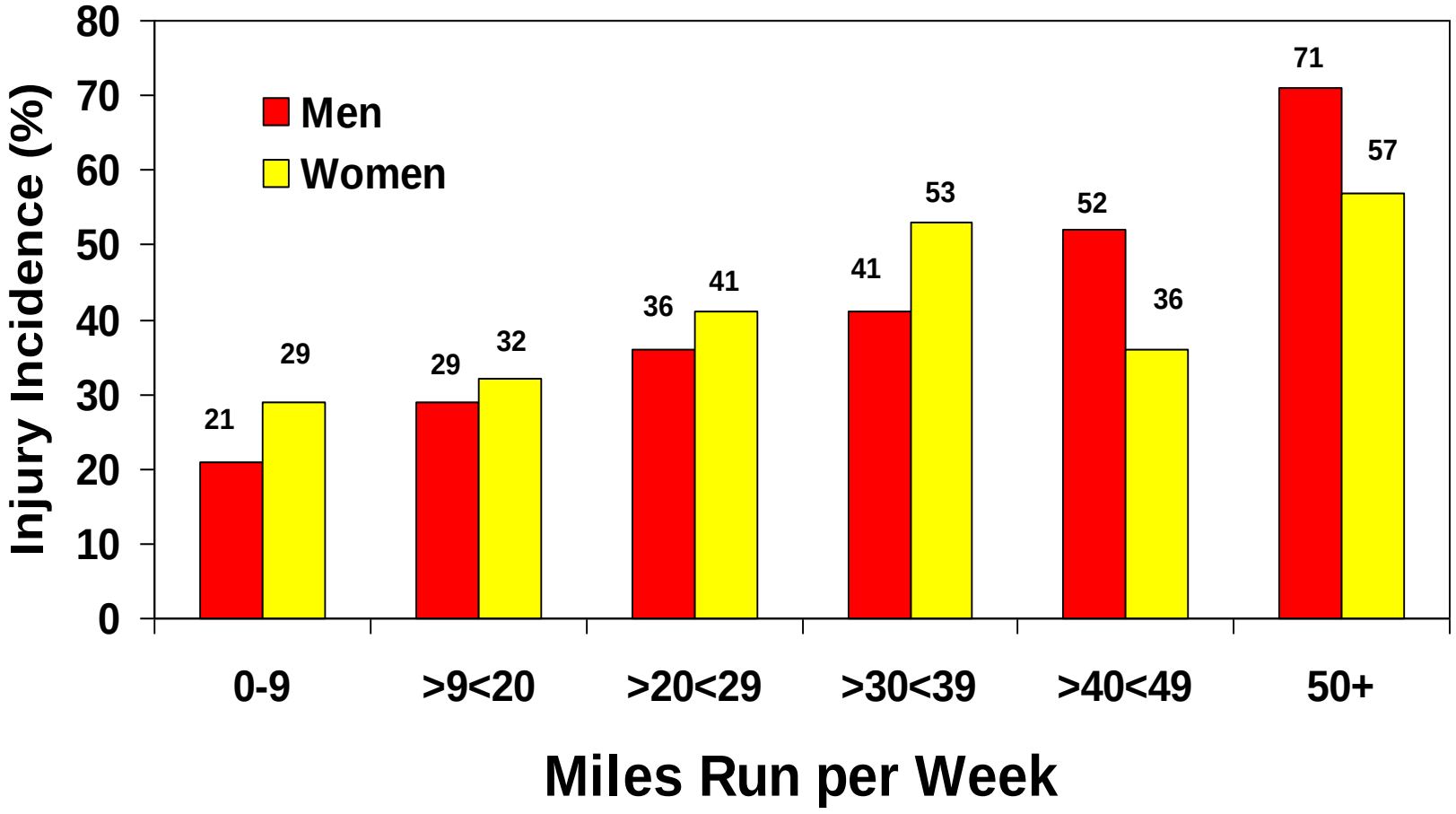
Five Key Public Health Questions		Five Steps of the Public Health Approach
1.Is there a problem and how big is it?	→	1.Surveillance
2.What causes the problem?	→	2.Research & field investigations
3.What works to prevent the problem?	→	3.Intervention trials & systematic reviews
4.Who needs to know and do what?	→	4.Program and policy implementation
5.How effective is what we have done?	→	5.Public health evaluations & monitoring

Factors Affecting Risks of PA-Related Injury

- Amount of current physical activity
- Type of current activity
- Amount of past physical activity
- Levels of physical fitness
- Health behaviors
- Anatomic and tissue factors
- Demographics/effect modifiers (age, gender)

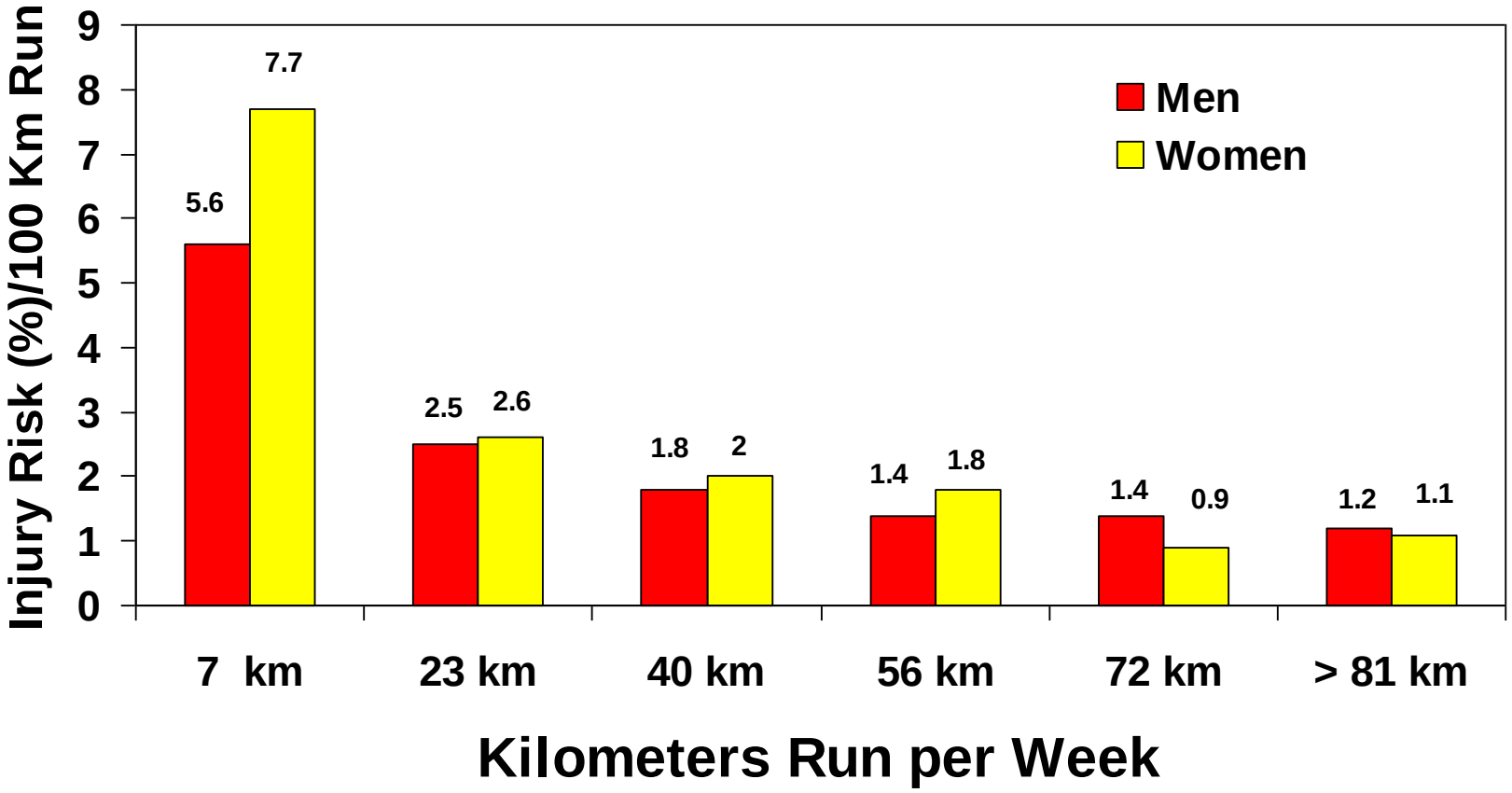
Amounts of Current Running or Walking and Injury Risks

Injuries per Year among Men and Women by Miles Run per Week



Koplan JP, Powell KE, Sikes RK.
JAMA; 248:3118, 1982

Estimated Injuries Risks among Men and Women by Kilometers Run per Week



Secondary analysis of data from Koplan JP, Powell KE, Sikes RK. JAMA; 248:3118, 1982

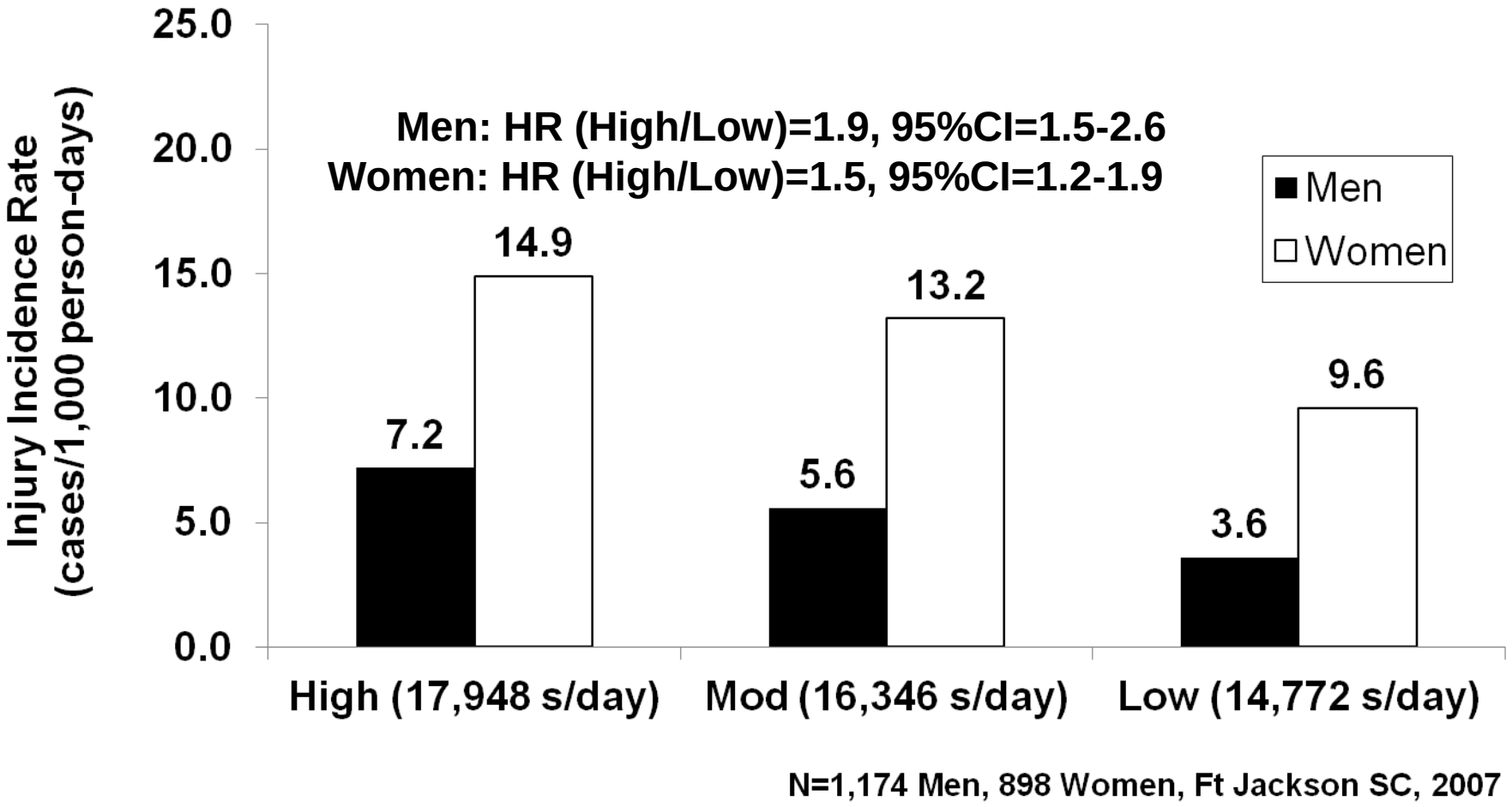
Source: Jones BH Sport Med 18 (3): 202-14, 1994

Walking: Relative Odds of Injury by Daily Duration for Men and Women

Walking (mins/day)	Men		Women	
	OR for Injury	(95% CI)	OR for Injury	(95% CI)
< 15	1.0	----	1.0	----
15 - 30	1.0	(0.7 -1.4)	0.8	(0.5 - 1.3)
> 30	0.8	(0.6 - 1.2)	1.4	(0.9 - 2.4)

Source: Colbert LH, et al. J. Sports Med 10 (4): 259-263, 2000

Association Between Physical Activity and Injury in Basic Combat Training



Knapik, J Phys Act Health 8:496, 2011

Amount of Physical Activity and Injury Risk

- Greater amounts[1] of running result in higher rates of injuries among civilian runners, exercise participants and military recruits.
- Confirmatory studies:
  - **Runners**
    - Brunet ME et al. J Sports Med Phys Fitness, 30: 1990
    - Colbert LH, et al. Clin J Sport Med 10: 259-263, 2000
    - DHHS (Powell K) Phys Act Guidelines 2008
    - Marti et al Am j Sports Med 1986
    - Macera C, et al. Arch Intern Med 149: 2565-2568, 1989
    - Walter SD, et al. Arch Intern Med 149: 2561-2564, 1989
  - **Military Recruits**
    - Almeida SA et al. MSSE 31 (8): 1176-1182, 1999

Note: 1) **Amount of Training = (Duration X Frequency X Intensity)**

Effects of Training Duration on Incidence of Injury and Endurance (VO_2 max)

Duration mins/day	Injury Incidence	Change in Endurance
0	0%	0.0%
15	22%	8.6%
30	24%	16.1%
45	54%	16.9%

Training: Running 3 days/wk, 85-90% Heart Rate max

Pollock, Ml. Med Sci Sports.
9(1); 31-36, 1977.

Effects of Training Frequency on Incidence of Injury and VO2 max

Days/Wk	% Injuries	% VO2 max (increase)
1	0%	8.3%
3	12%	12.9%
5	39%	17.4%

Training 30 Min/ day, 85-90% Heart Rate Max.

Pollock, Ml. Med Sci Sports.
9(1); 31-36, 1977.

Effects of High and Low Running Mileage on LE Injury Rates and Run Times in Infantry IET

Mileage	Injury Incidence	2 Mile Run Time*
Low (n = 146)	32.5%	13:29
High (n = 157)	41.8%	13:45

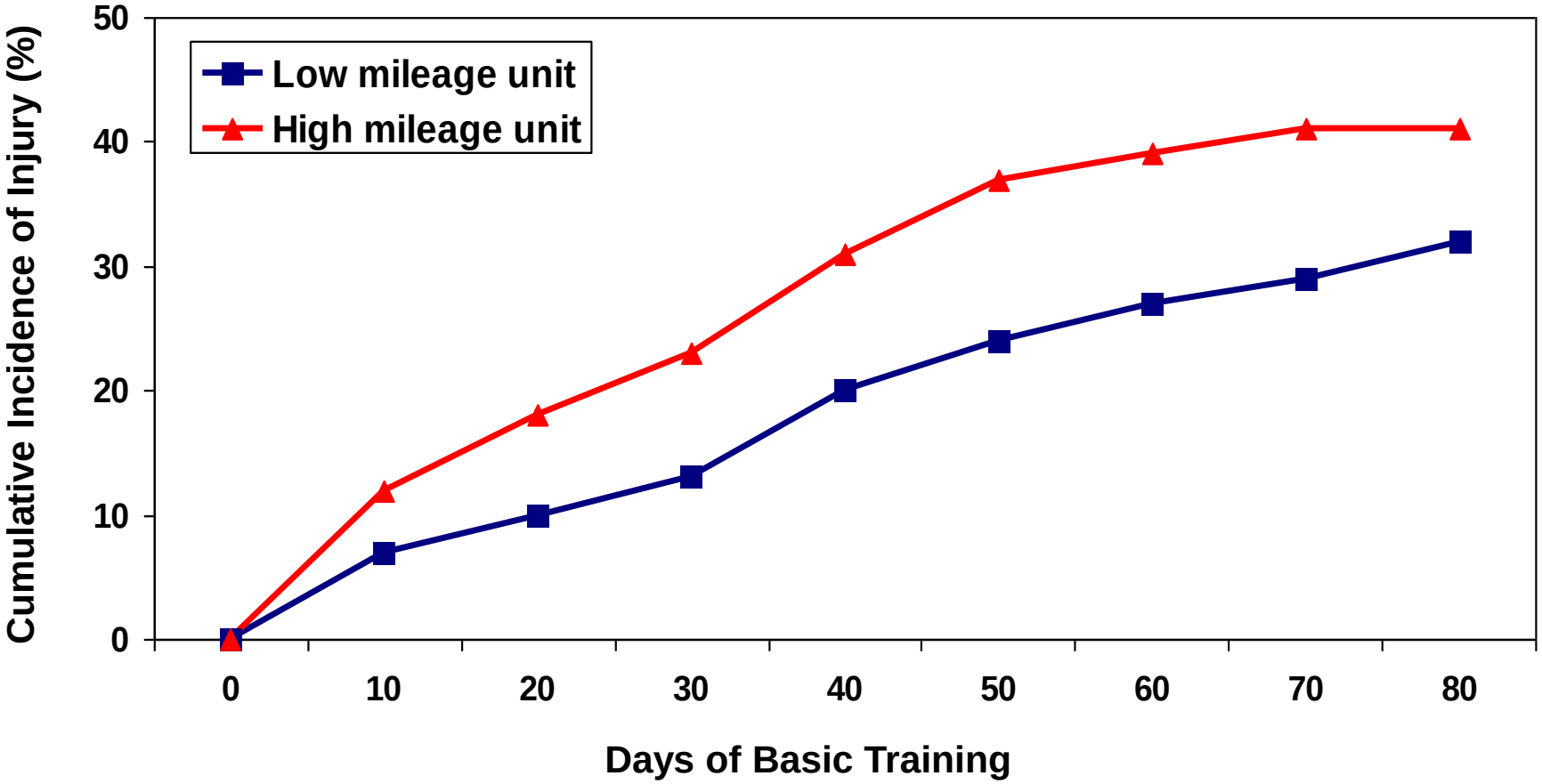
* Final APFT Average Times Ft Benning 1987

RR high v low = 1.3 (95% CI: 1.0-1.8)

Low Mileage = 56 miles/12 wks; High Mileage = 130 miles/ 12 wks

Source: Jones BH et al. Sports Med 18 (3): 202-214, 1994

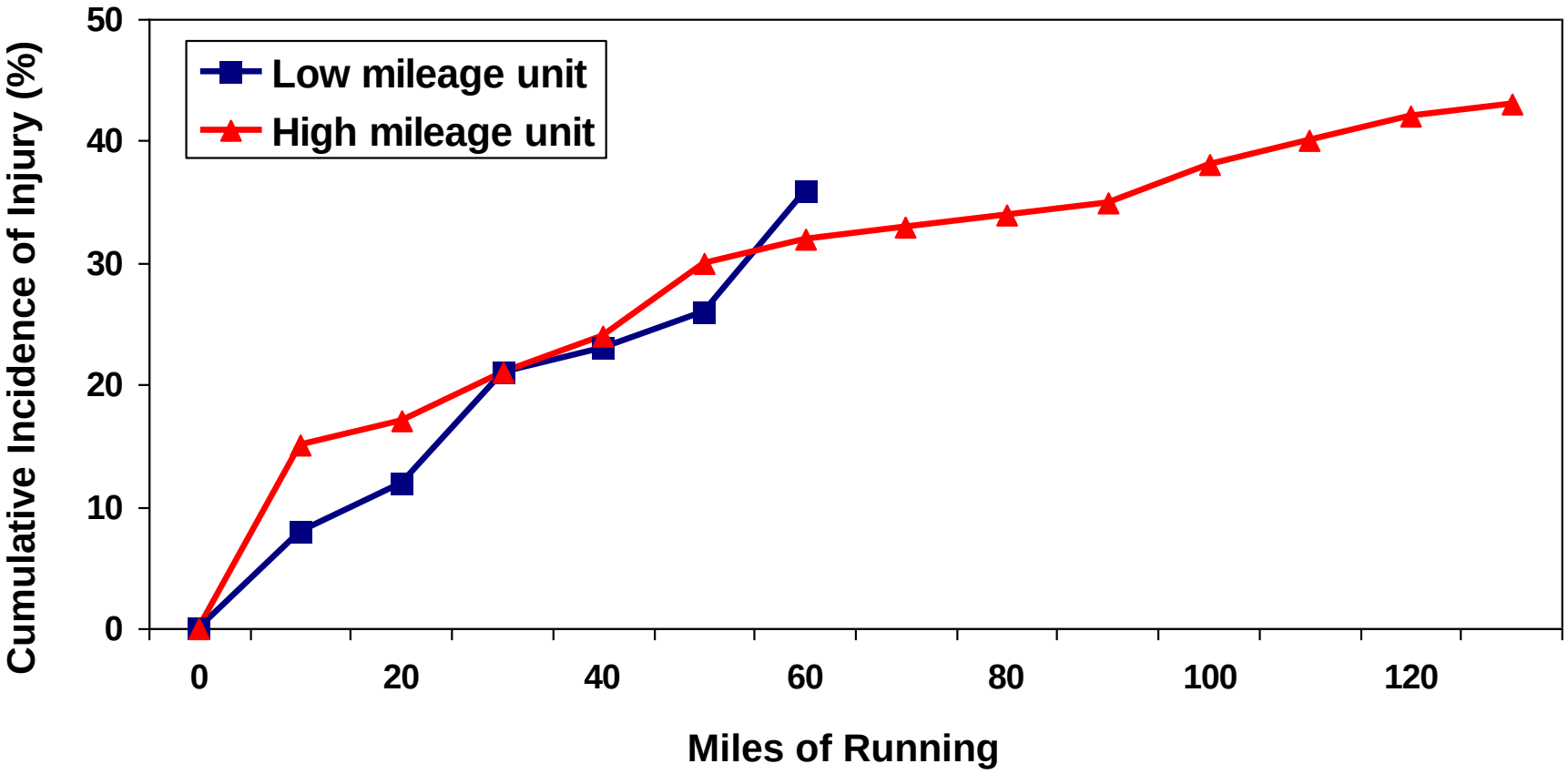
Cumulative Injury Incidence by Cumulative Days of Training in 12 weeks of Army Infantry Basic Training



Low mileage unit: n=157, miles=56 (90 km)
High mileage unit: n=146, miles=130 (280km)
Survival analysis (100 - % injured), p=0.02

Jones BH: Sports Med; 18;202-14, 1994.

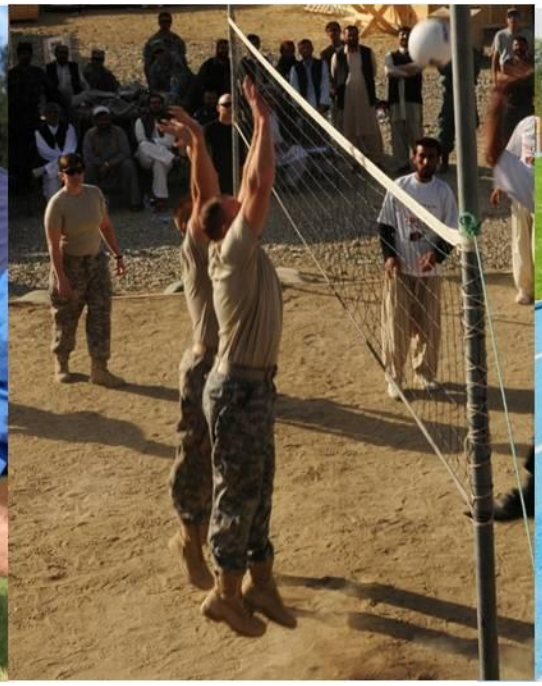
Cumulative Injury Incidence by Cumulative Running Mileage in 12 weeks of Army Infantry Basic Training



Low mileage unit: n=157, miles=56 (90 km)
High mileage unit: n=146, miles=130 (280km)

Jones BH: Sports Med; 18;202-14, 1994.

Type of Activity and Injury Risk


See DHHS Phys Activity Guidelines Committee Report Part G. Section 10, 2008

Injury+ Risks Among Men and Women by Type of Physical Activity

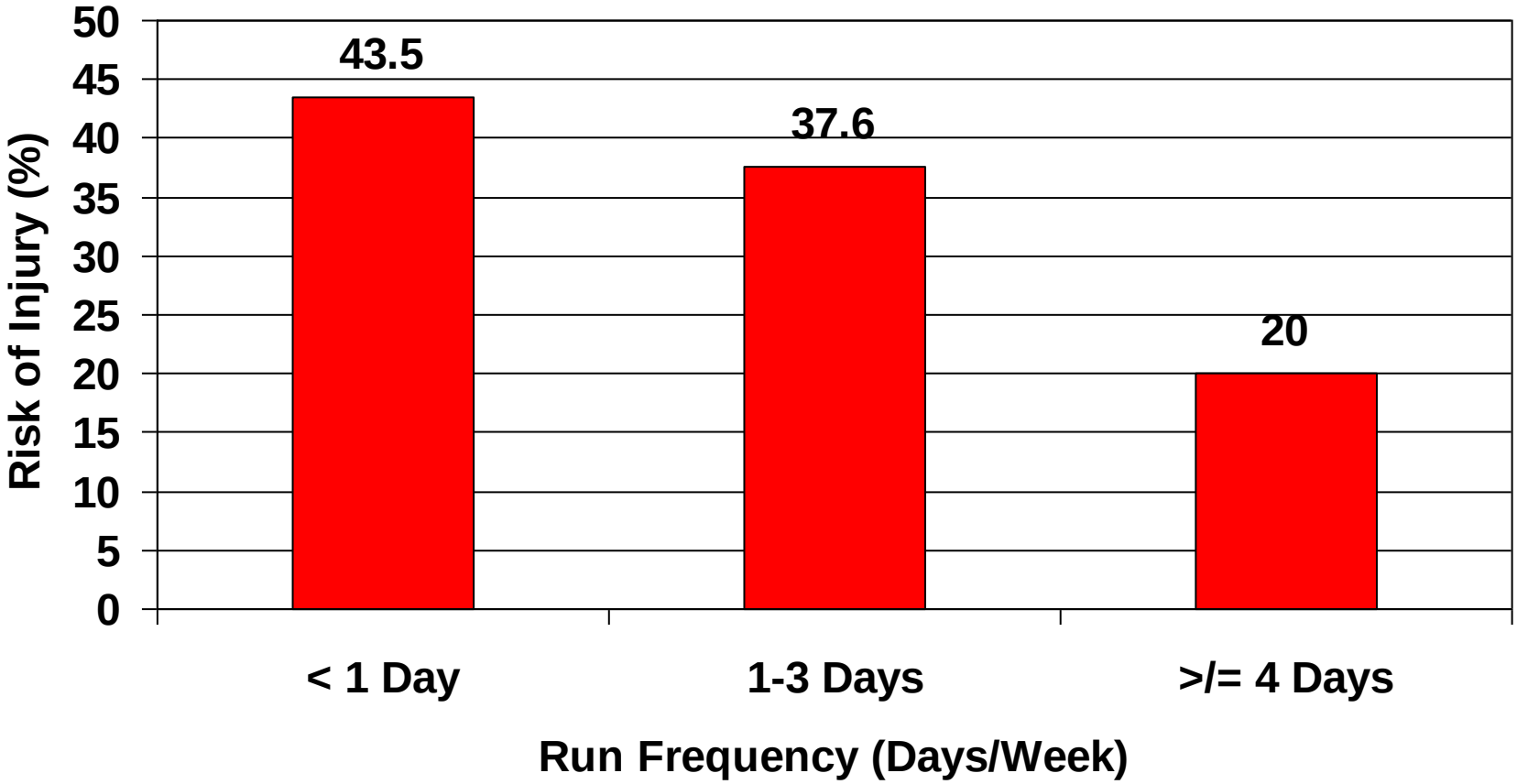
Type of Activity	Men - 5,028 Risk (%/yr)	Women - 1,283 Risk (%/yr)
Sedentary (1,608 m, 501 w)	14.6* (RR = 1.0)	16.8* (RR = 1.0)
Walking (508 m, 206 w)	16.5 (RR = 1.14)	19.9 (RR = 1.18)
Running (2,445 m, 405 w)	24.7 (RR = 1.78)	23.2 (RR = 1.38)
Sports (467 m, 101 w)	27.6 (RR = 1.89)	26.7 (RR = 1.59)

+ Self-reported injury in previous year
* Significantly lower than all activities, Chi sq $p < 0.05$

Hootman JJ et al. MSSE 34 (5):838-844, 2002

Past Physical Activity and Risks of Injury

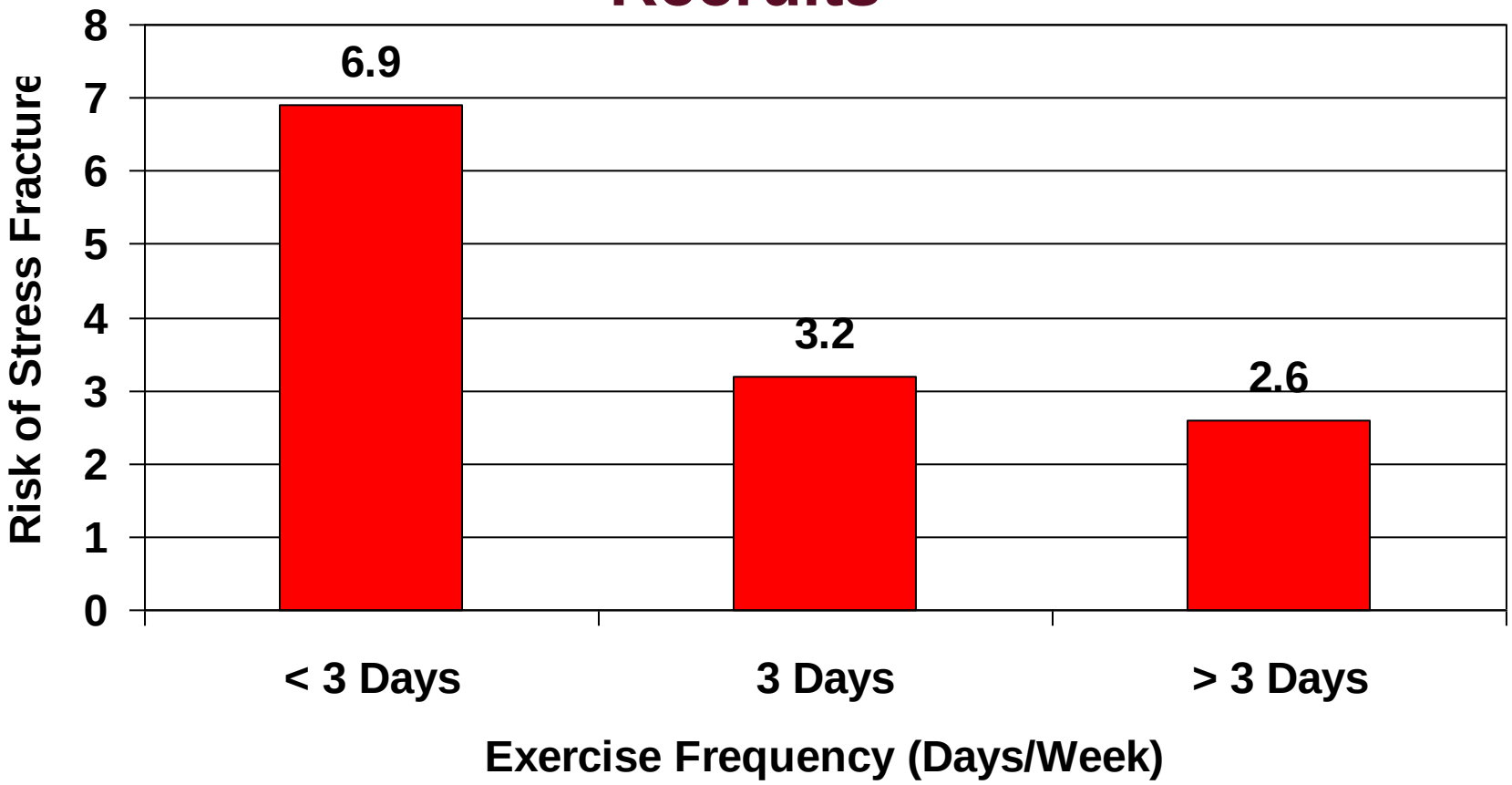
Days Run per Week the Month Before IET* and Injury Risk in Male Army Trainees



* Initial Entry Training, 12 Weeks, Ft Benning, GA 1987
N = 289 Trainees (0-1 d 108, 1-3 d 149, > 4d 45)
$RR_{0\text{-}1\ d/>\ 4\ d} = 2.2$, 95% CI: 1.2-4.1

Jones BH, MSSE, 25 (2): 197-203, 1993

Exercise Frequency in Two Months Before IET* and Risk of Stress Fractures in Male Marine Recruits



Marine Corps Initial Entry Training, MRCD San Diego, CA 1995
N = 1,286 (< 3d 658, 3d 300, > 3d 328)
RR <3d/> 3d = 2.7, 95% CI: 1.3-4.6, Trend p < 0.00

Shaffer R, et al.
AJE 149: 236-42, 1999

Greater Frequency or Duration of Past PA Associated with Lower Risk of Current Injury

Confirmatory Studies

- Jones BH et al MSSE 1993
- Knapik JJ et al J Strength Cond Res 2009
- Knapik JJ et al MSSE 2001
- Rauh MJ et al MSSE 2006
- Shaffer RA et al Am J Sports Med 2006
- Shaffer RA et al AJE 1999

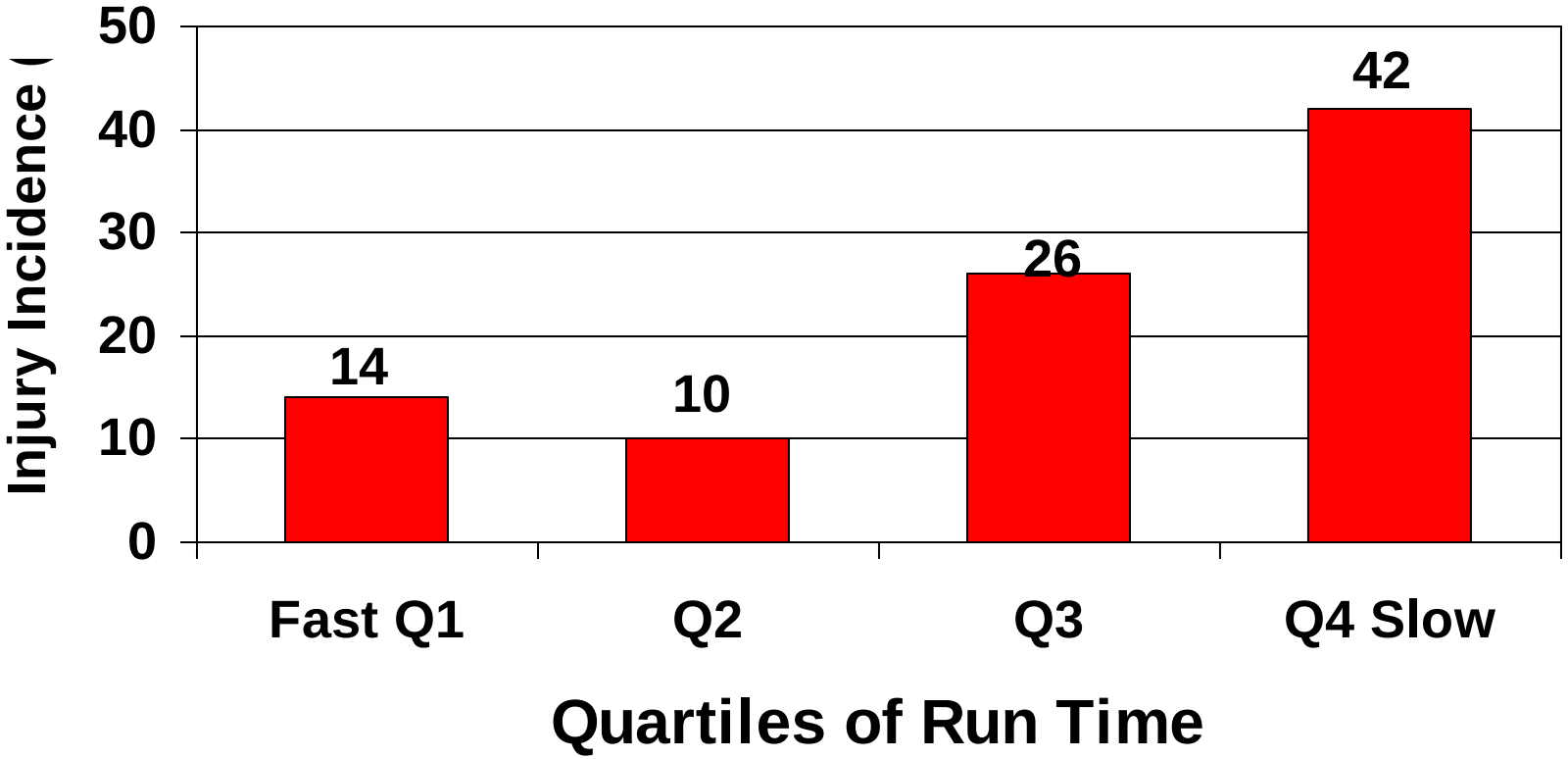
Components of Physical Fitness and Risks for Injuries

Health Related Components of Fitness Identified by the 1984 PA Workshop

- Endurance
- Muscle Endurance
- Muscle Strength
- Flexibility
- Body Composition

Aerobic Fitness and Injuries

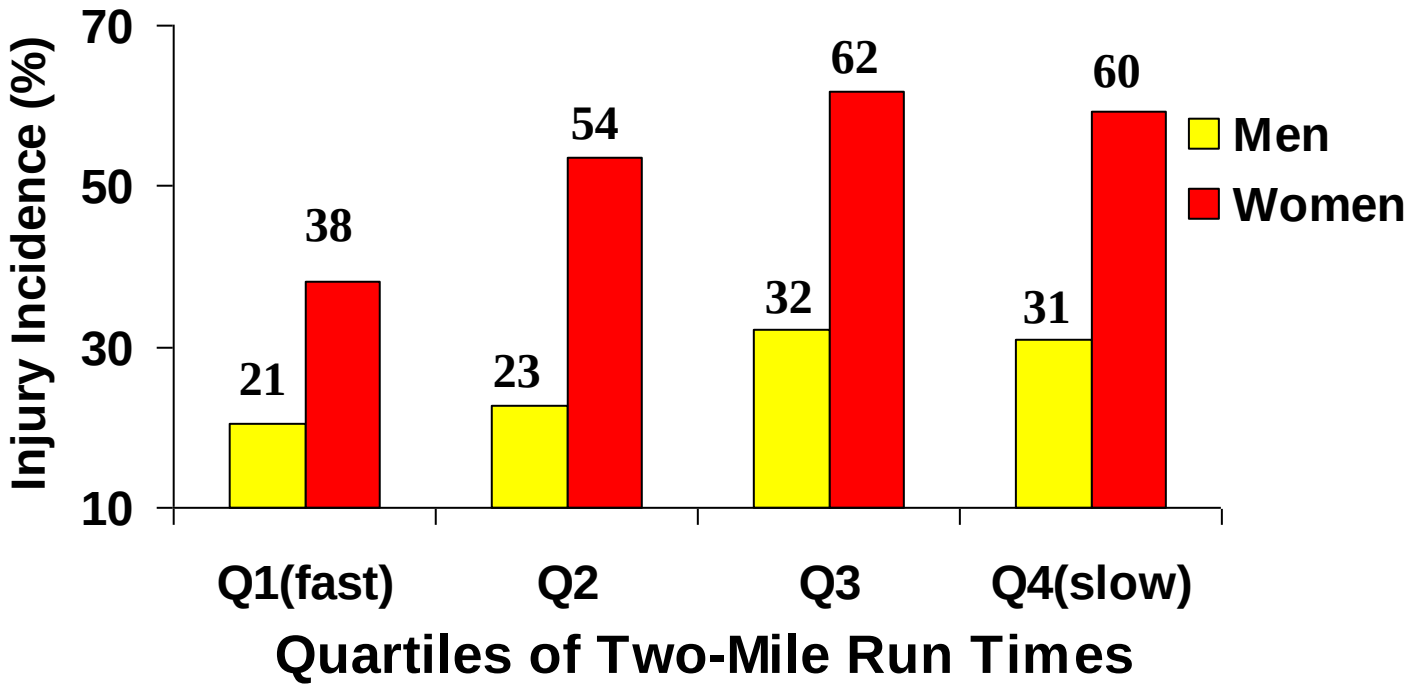

Mile Run Times and Incidence of Injury among Male Army Basic Trainees



Ft. Jackson, 1984; N= 79, 8 weeks BCT
P-value for trend= .02
Median run time (mins) = 7.1

Source: Jones BH. Body Composition & Physical Performance. National Academy Press, pp141-173, 1992.

Association of Two-Mile Run Time With Time-Loss Injuries in Army BCT



N=682 Men, 387 Women; Risk Ratio(Q4/Q1):Men=1.5, Women=1.6

p-value for trend: Men=<0.01, Women=<0.01

Source: Knapik JJ, USACHPPM Tech Report No. 29-HE-8370-98, 1998

Faster Run Times (Higher Aerobic Fitness) Associated with Lower Risk of PA-related Injuries

Confirmatory Studies

- DHHS (Powell K) Phys Act Guidelines 2008
- Jones BH et al Am J Sports Med 1993
- Knapik JJ et al AJPM 2010
- Knapik JJ et al J Strength Cond Res 2009
- Knapik JJ et al MSSE 2001
- Knapik JJ et al JOM 1993
- Rauh MJ et al MSSE 2006
- Reynolds K et al AJPM 1994
- Shaffer RA et al Am J Sports Med 2006

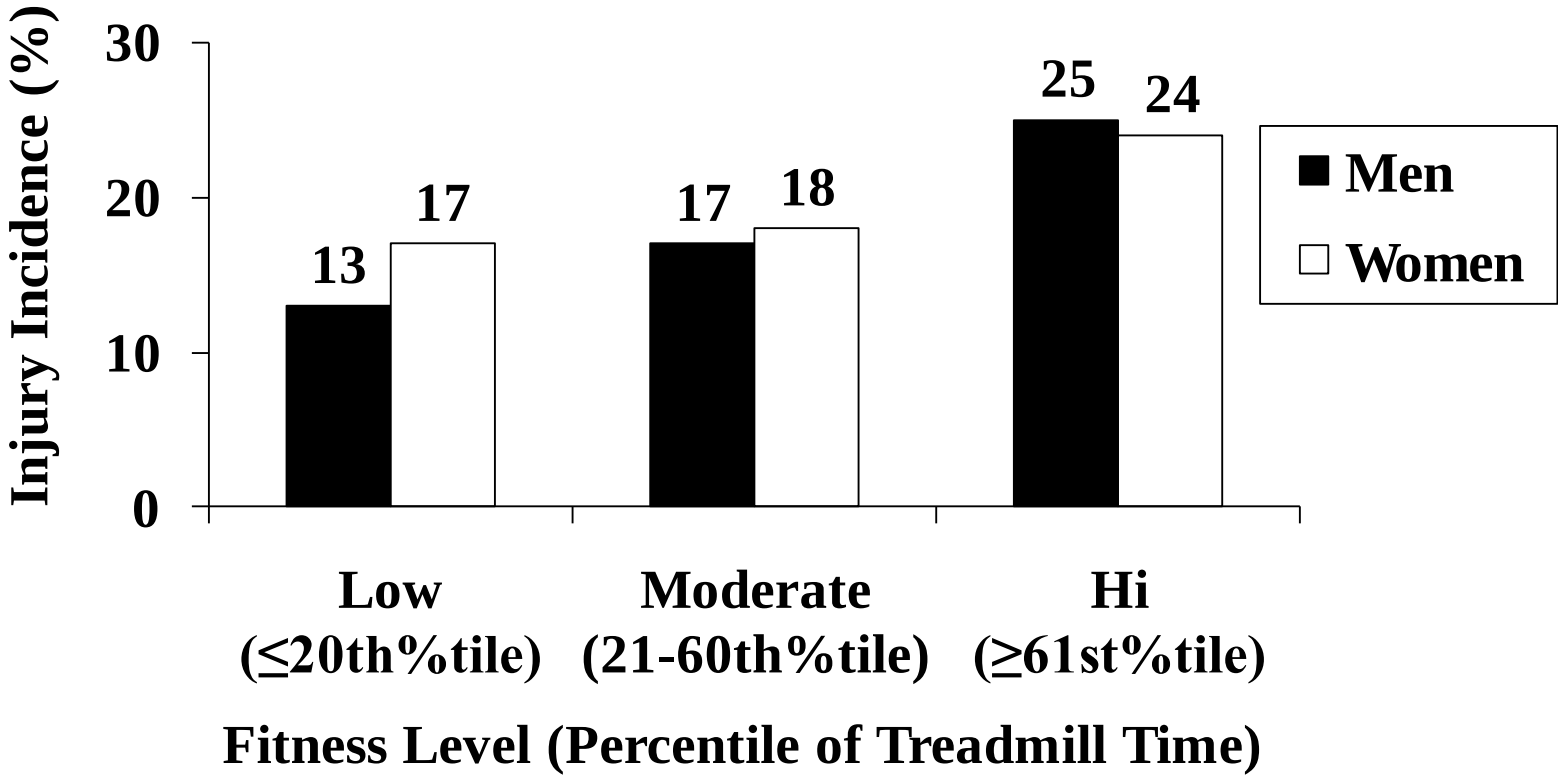
Improvement in 2-Mile Run Times Among Army Recruits by Quartile of Initial PT Test Run Time, 9 Weeks BCT

Quartile of 2-mile time	Initial 2-mile run time avg (mins)	Final 2-mile run time avg (mins)	Change in time (mins)	Percent (%) change
Q1 Fast	15.0	13.9	1.1	7.3%
Q2	17.6	15.1	2.5	14.2%
Q3	20.1	16.6	3.5	17.3%
Q4 Slow	23.8	18.3	5.5	23.1%

N = 26,695 Recruits (15,901 men, 10,794 women)

Source: Knapik JJ, et al Milit Med 171: 669-677, 2006

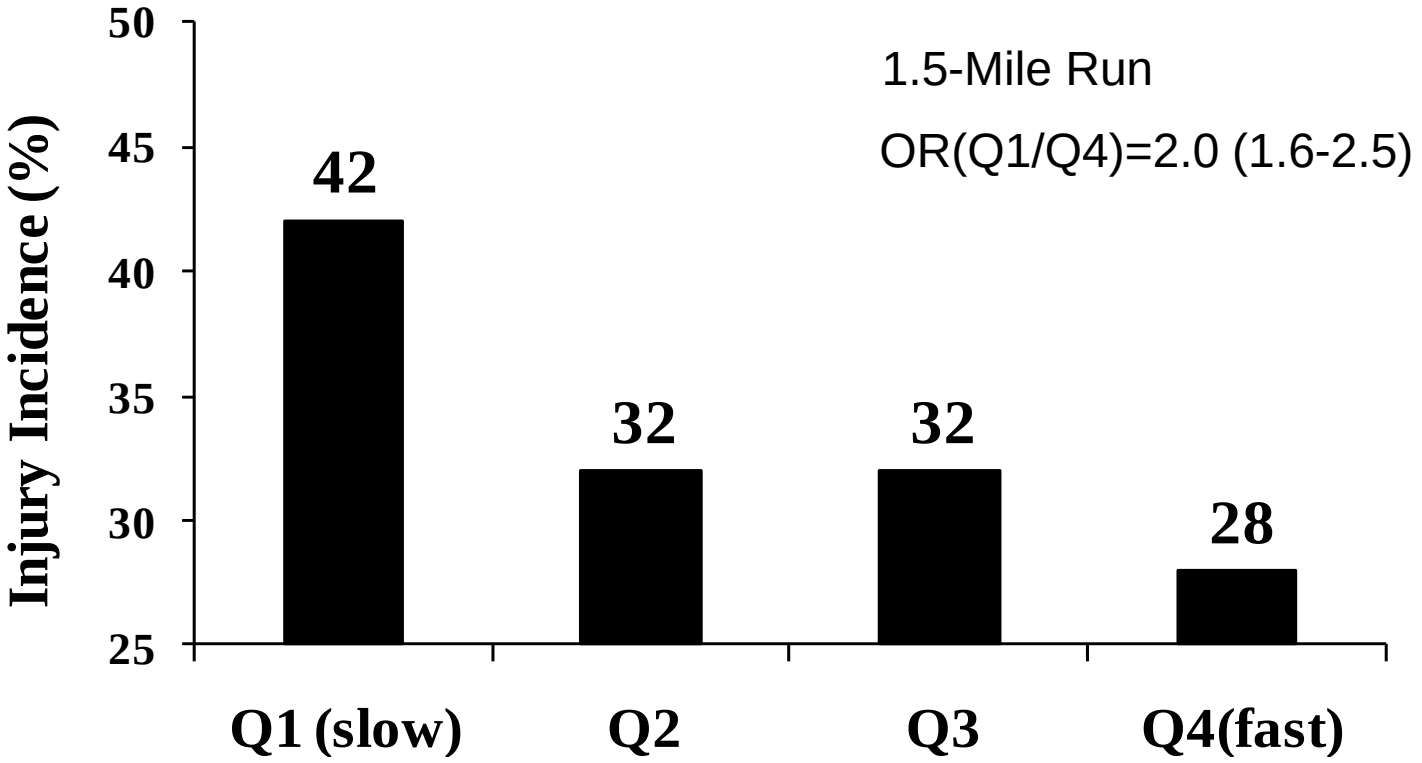
Association between Treadmill Time and Injuries Among Cooper Clinic Participants



Risk Ratio (hi/lo): Men=1.9, Women=1.4

Hootman, Med Sci Sports Exerc 34:838, 2002

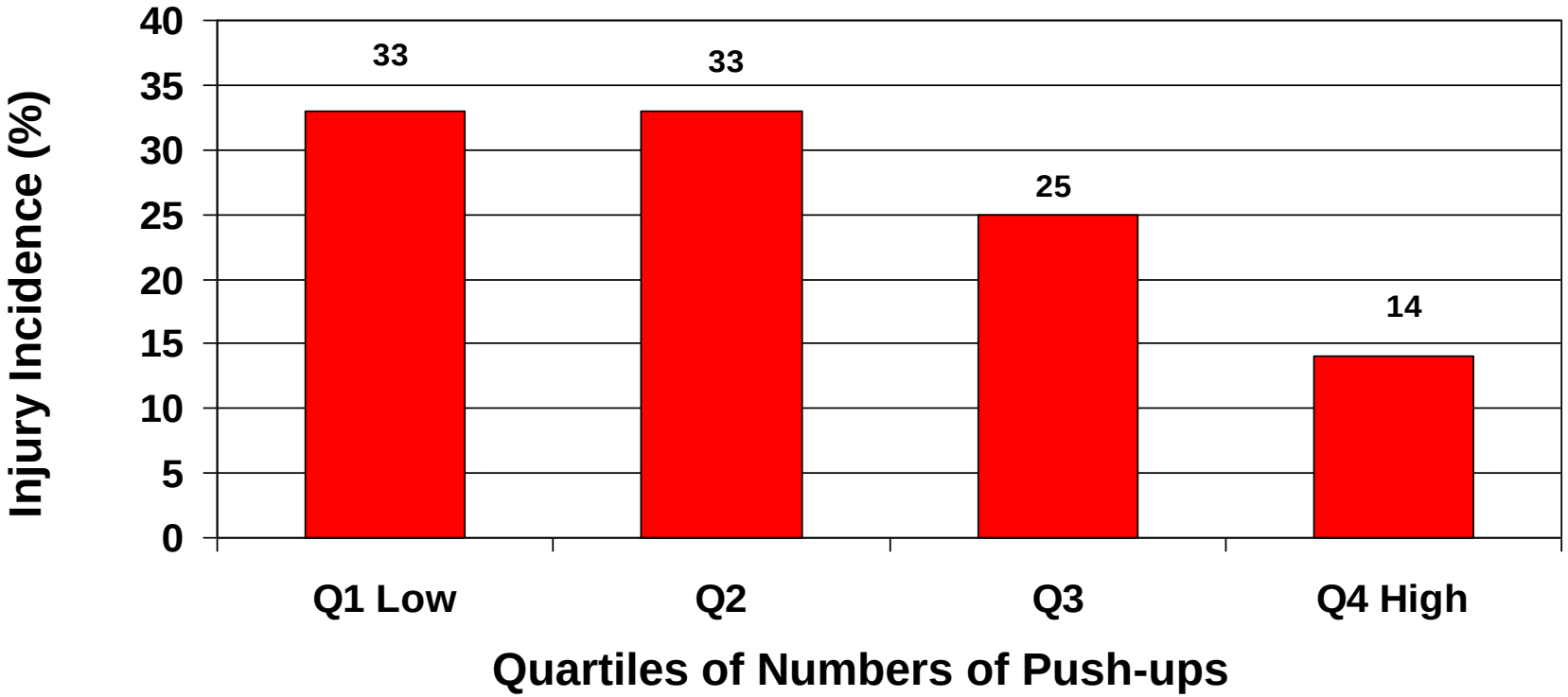
Association Between Aerobic Fitness & Injuries Among Male FBI New Agent Trainees



Knapik, USAPHC Technical Report No. 12-HF-97HRF1-09, 2009

Muscle Endurance, Muscle Strength and PA-Injury Risks

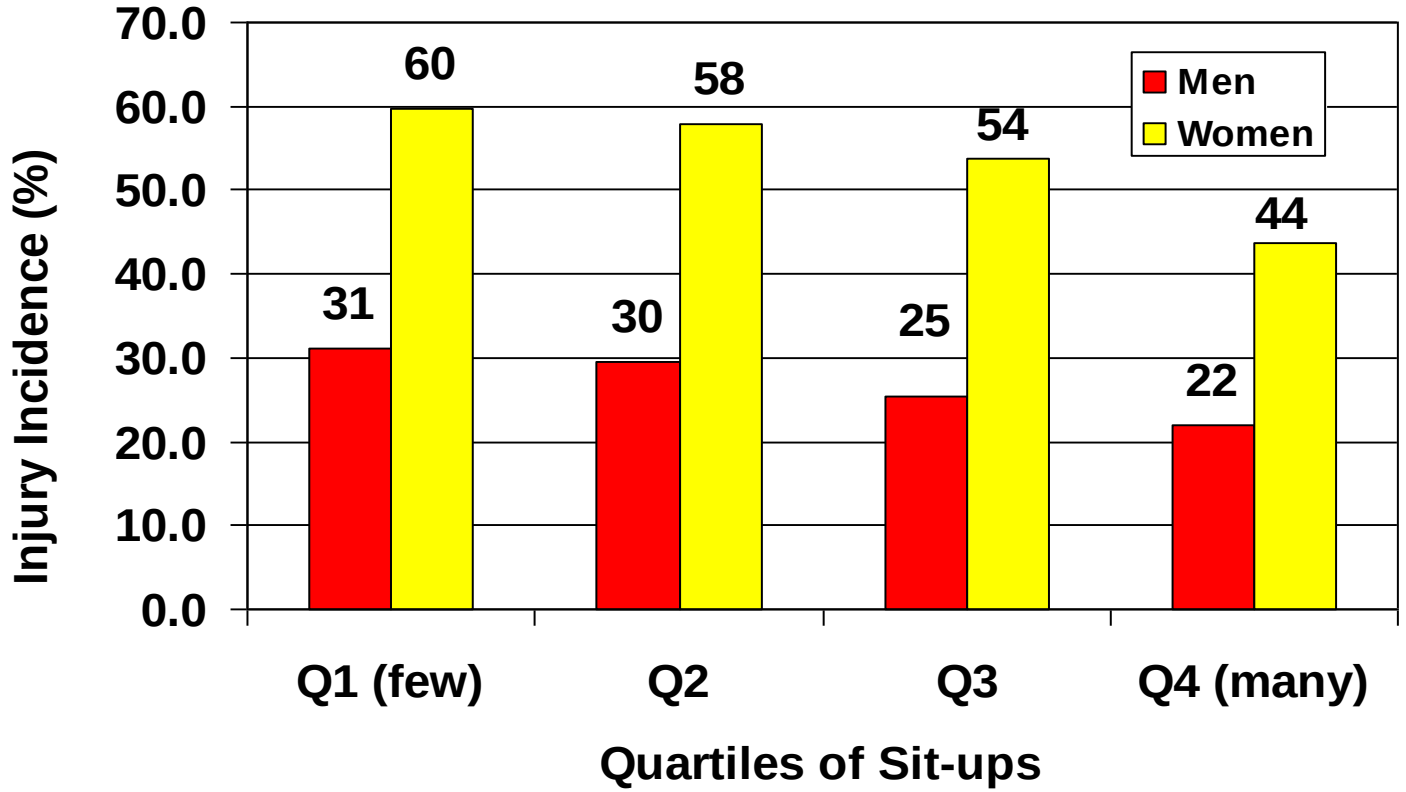
Push-ups and Injury among Men in Army Basic Training



Ft. Jackson, 1988 N= 97, 8 weeks of training
MH Chi Trend= 2.6, p= 0.10
Average push-ups = 31 ± 9

Jones, B.H. USARIEM Army Technical Report #: T19-88, Natick, MA, 1988.

Association of Sit-Ups Performance with Time-Loss Injury in BCT



N=687 Men, 392 Women; Risk Ratio(Q1/Q4):Men=1.4, Women=1.4
p-value for Trend: Men=0.04, Women=0.02
(Ft Jackson, 1998)

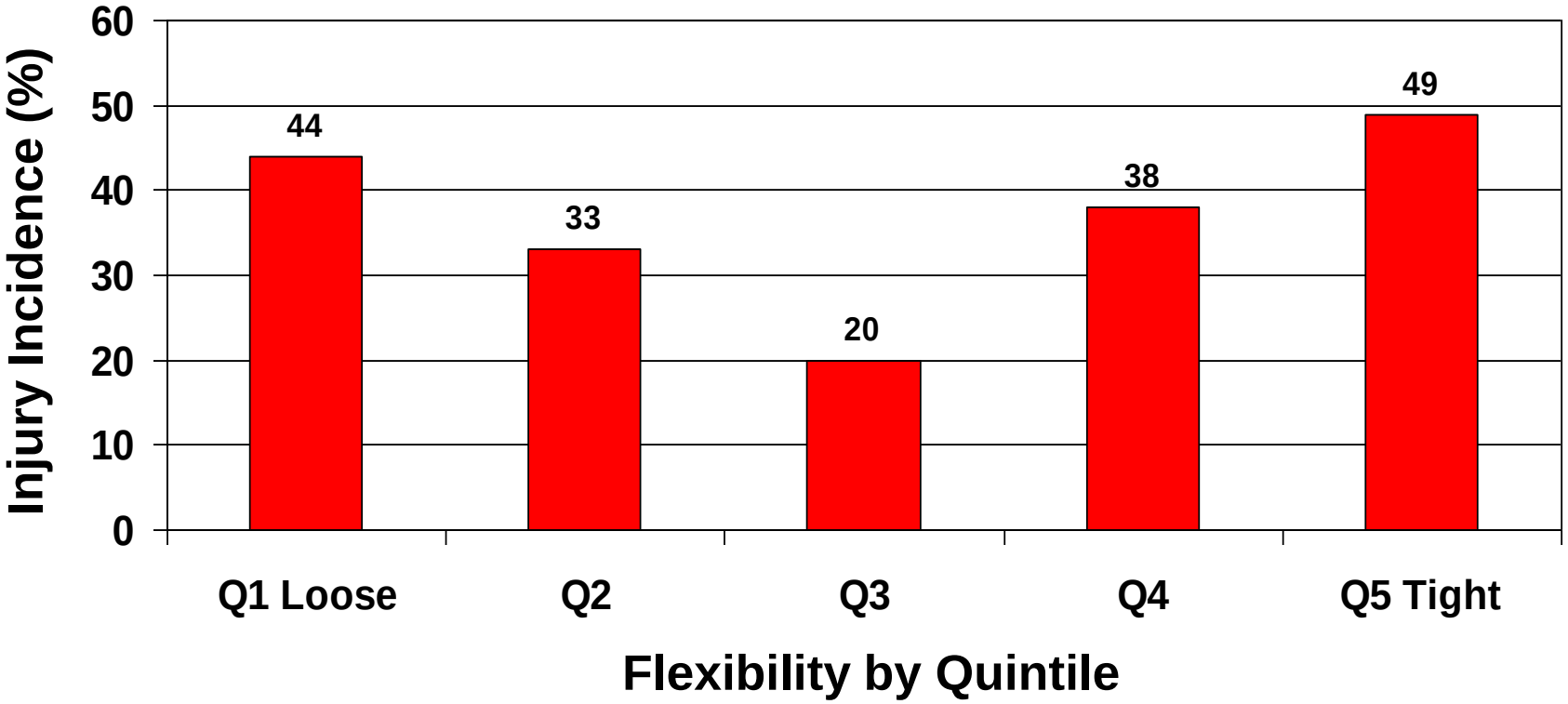
Knapik, USACHPPM Epicon Report No 29-HE-8370-99, 1999

Muscle Endurance, Muscle Strength and PA-Injury Risks

- Muscle endurance for military personnel shows similar association to injury risk as that of aerobic fitness:
  - The associations are weaker and less significant (curves flatter)
  - Measurements primarily push up and sit up performance
  - References: Bell NS AJPM 2002; Jones BH Am J Sports Med 1993, MSSE 1994; Knapik JJ AJPM 2010, Knapik JJ J Strength Cond Res 2009, Knapik JJ MSSE 2001
- Muscle strength shows inconsistent association with injury risk:
  - Associations are weaker than for aerobic fitness or mucsle endurance, less significance.
  - Measurements employ a variety of dynamic and static strength tests
  - References: Jones BH MSSE 1993, Knapik JJ MSSE 2001; Westphal KA Army 1996

Flexibility and Injury Risk

Flexibility (Sit and Reach) and Injury among Men in Infantry Basic Training



Ft. Benning, 1987; N= 303, Median= 4.3cm (RNG= -24 to +28)
RR Q1 vs Q3= 2.2, p-value <.05
RR Q5 vs Q3= 2.5, p-value <.05

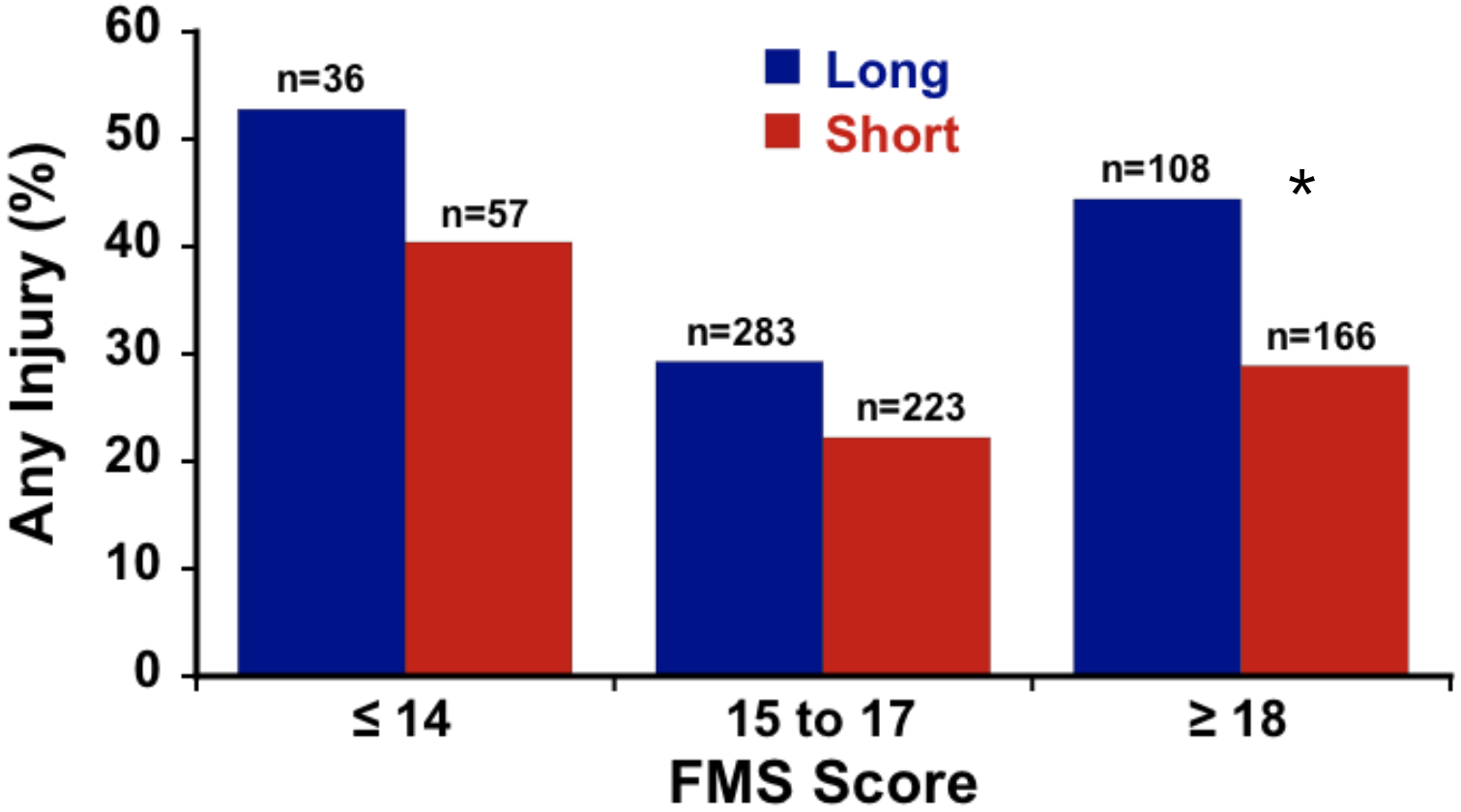
Jones, BH et al
MSSE Vol 25(2), 1993

Flexibility

Other confirmation of bimodal association of flexibility with PA injury risk:

- Jones BH et al Am J Sports Med 25, 1993
- Knapik JJ et al Sports Med 14: 277-88, 1992
- Knapik JJ et al. MSSE 33 (6): 946-954, 2001

Injury Incidence by Functional Movement Screening (FMS) Scores* among Marine Officer Candidates



FMS assesses combination of flexibility, balance and movement in 7 tests.
Marine Officer Candidates Long Course 68 days, Short Course 38 days.

Papas CG, ACSM 2011

Body Composition and Injury Risks

- The association of body composition and PA-related injury risks is inconsistent
  - Some studies show that low BMI is associated with higher risk (Macera Ann Int Med 1989, Taunton JE Br J Sports Med 2003)
  - Some show high BMI or % BF is a risk factor (Hootman JM Clin J Sports Med 2002, Knapik JJ et al AJPM 2010 (women)
  - Others show a pattern of association of BMI or % BF that is J-shaped or bimodal with highest and lowest at greater risk (Jones BH et al Am J Sports Med 1993; Jones BH Nat'l Acad Press 1992; Knapik JJ AJPM 2010 (men); Reynolds K et al AJPM 1994)
  - Others show no association (Knapik JJ et al J Strength Cond Res)

Aerobic Fitness (Run Times) Stratified on Body Composition (BMI)

Risk of Injury (%) by Quartiles of Run Time and Level of BMI for Men During BCT

BMI Lvl	Run Fast Q1	Q2-3	Run Slow Q4	Total
BMI Low Q1	16.5; 1.0 (ref)	21.4; 1.3 (0.9-1.8)	28.7; 1.7 (1.2-2.6)	20.7%
Q2-3	19.6; 1.2 (0.8-1.0)	19.3; 1.2 (0.9-1.6)	25.1; 1.5 (1.1-2.1)	20.5%
BMI High Q4	20.5; 1.2 (0.7-2.1)	19.8; 1.2 (0.9-1.7)	26.5; 1.6 (1.2-2.2)	22.8%
Total	18.6%	20.0%	26.2%	

Analysis 1: n=2,945
Cells contain: (% injured; RR (95% CI)

NRC. Assessing Fitness for Military Enlistment, Chapt. 4, Nat'l Academy Press, 2006

Risk of Injury (%) by Quartiles of Run Time and Level of BMI for Women During BCT

BMI Lvl	Run Fast Q1	Q2-3	Run Slow Q4	Total
BMI Low Q1	45.0; 1.0 (ref)	52.2; 1.2 (0.9-1.4)	60.8; 1.4 (1.1-1.7)	50.9%
Q2-3	35.7; 0.8 (0.6-1.0)	47.7; 1.0 (1.0-1.1)	55.2; 1.2 (1.0-1.5)	45.7%
BMI High Q4	38.2; 0.9 (0.6-1.2)	48.3; 1.1 (0.9-1.3)	50.8; 1.1 (0.9-1.4)	47.6%
Total	39.2%	48.9%	54.4%	

Analysis 1: n=2,080
Cells contain: (% injured; RR (95% CI)

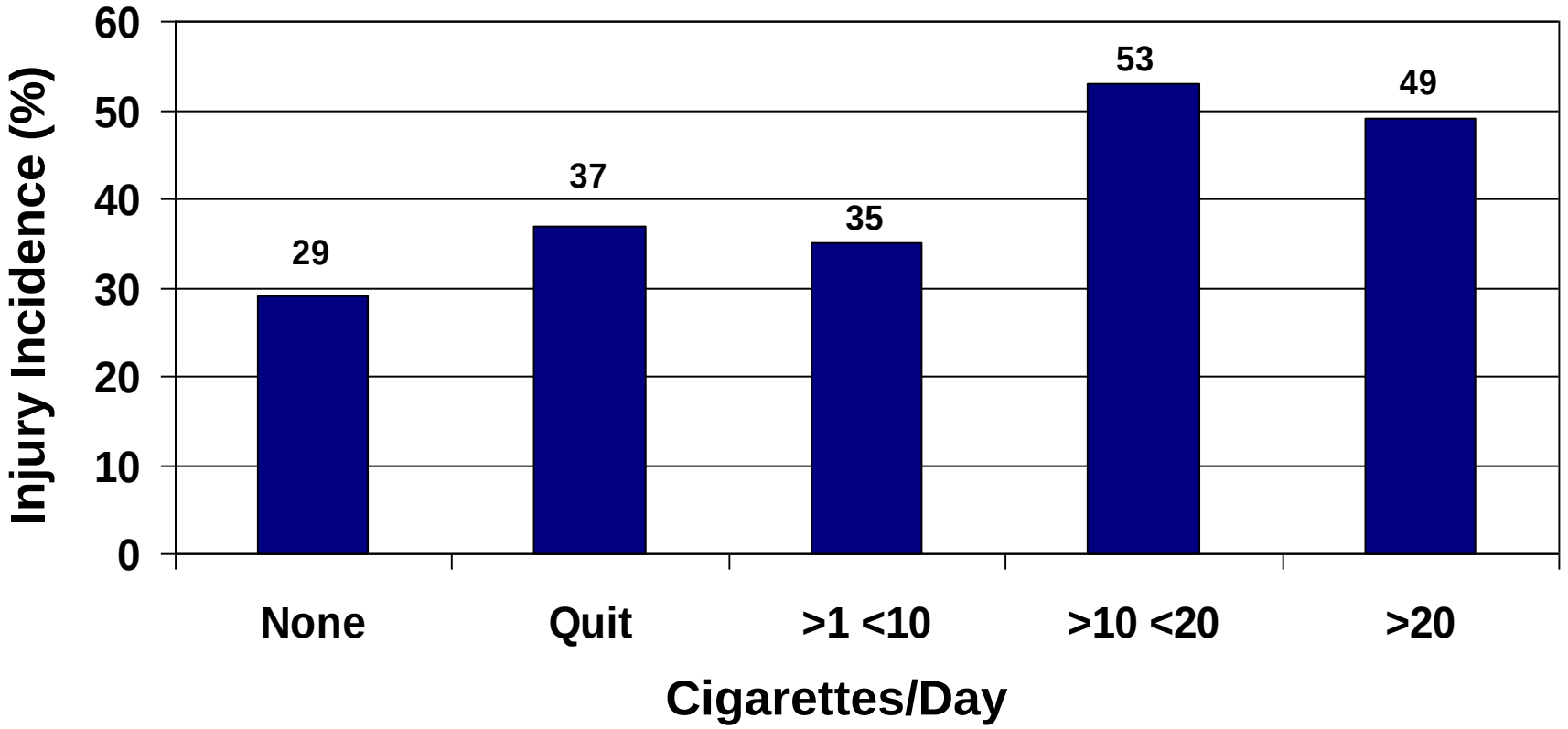
NRC. Assessing Fitness for Military Enlistment, Chapt. 4, Nat'l Academy Press, 2006

Health, Health Risk Behaviors and PA-Related Injury Risks

Health Behavior or Health Factor	Comparison of Risk	Range in RRs or ORs
Past Injury[1]	Past Inj Risk vs No Past Injury	1.4 to 2.7
Amenorrhea[2] (Stress Fx Risk)	Amenorrhea Risk vs Normal	1.7 to 8.5
Sedentary Life Style[3]	Inactive Risk vs Very Active	2.5 to 20.0
Smoking Cigarettes[4]	Smoking Risk vs Non-Smoking	1.7 to 3.0

1. Hootman JM 2002, Jones BH 1993; Macera C 1989, Walter SD 1989; **2**. Lloyd T MSSE 1986; Barrow GW Am J Sports Med 1988, Rauh M 2006; Shaffer R 2006; **3**.Gardner L AJPH 1988; Jones BH 1992, 1993; Knapik JJ 2001, **4**. Altarac M 2000; Jones BH 1993; Knapik 2001; Reynolds K 1994

Cigarette Smoking and Lower Extremity Injuries among Male Infantry Trainees



Ft. Benning, 1987, 12 Wk F/U, N= 299
Chi Sq p<.05

Jones, B.H. et al
MSSE Vol 25(2), 1993

Other Possible Risk Factors (cont.)

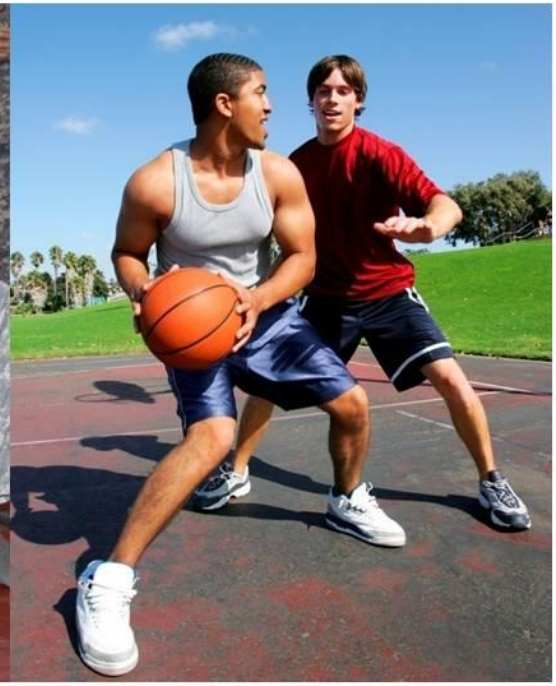
Anatomy/Structure

- Evidence suggests that some anatomic variants are associated with risk of injury
  - **Knock-knees** – greater risk Cowan1996
  - Bowed legs – lower risk than knock knees Cowan D. 1996
  - **Higher Q-angle** – greater risk Cowan1996, Rauh 2005
  - **Unequal leg length** – greater risk Brunet ME 1990, Cowan 1994
  - **High arched feet** – highest risk Cowan 1996, Giladi 1985, Knapik JJ et al J Strength Cond Res 2009 (Men)
- Insufficient evidence to conclude that such variants can be corrected to prevent injuries

Other Possible Risk Factors (cont.)

- Tissue Physiology/Adaptation/Repair
  - Bone
  - Muscle
  - Tendon
  - Ligament
- Evidence shows that the above tissues adapt to increased physical activity and exercise (Reviews: Maganaris CN, Sports Med 2004; Maffuli N et al. Sports Med 1992; Sharma P, J Musculoskelet Neuronal Interact 2006)

Demographic Factors/Effect Modifiers of PA-Related Injury Risk



Age and Injury Risk

- Studies showing older age associated with higher risk of injury
  - Brudvig TJ et al. Milit Med 148: 666-7, 1983
  - Gardner LI et al. AJPH 78:1563-7, 1988
  - Jones BH et al. MSSE 25 (2): 197-203, 1993
  - Knapik JJ et al. Milit Med 171: 45-54, 2006
  - Knapik JJ et al. MSSE 33 (6): 946-54, 2001
  - McKean KA et al. Clin J Sport Med 16: 149-54, 2006
  - Shaffer RA et al. AJE 149: 136-42, 1999
  - Taunton JE et al. BJ Sports Med 37: 239-44, 2003
- Studies showing older age associated with lower risk of injury
  - Carlson SA et al. Ann Epi 16: 712-719, 2006
  - Colbert LH et al. Clin J Sport Med 10: 259-63, 2000
  - Hootman JM et al. Clin J Sport Med 12: 99-106, 2002
  - Knapik JJ et al. JOM, 1993

Incidence of Injury Among Women and Men During Army Basic Training

Study	Year	Women (%)	Men (%)	RR*
Kowal	1980	54	26	2.1
Bensel	1982	41	21	2.0
Jones	1984	50	28	1.8
Bell	1988	62	29	2.1
Canham	1995	64	42	1.6
Knapik	2000	47	17	2.8
Knapik	2003	48	28	1.7

***Relative Risk**

1. Kowal D: Am J Sports Med; 8(4), 1980
2. Bensel C: Army Tech Report, Natick
3. Jones BH et al: National Academy Press, 1992
4. Bell N et al: Am J Prev Med; 18(Suppl 3):141, 2000
5. Canham ML, et al: Advances in Occ Erg & Safety, 1998.
6. Knapik JJ: Int J Sports Med; 24: 372, 2003
7. Knapik JJ: Army Tech Report , USACHPPM

Mean Characteristics and Physical Fitness of Men and Women Trainees

Variable	*Men*	*Women*
Age (yrs)	20.2	20.2
Height (cm)	178.1	164.1
Weight (kg)	77.2	62.0
BMI (wt/ht^2)	24.3	23.0
2-Mile run (min)	17.7	22.7
Sit-ups (#)	41	33
Push-ups (#)	30	8

Ft. Leonard Wood, 1995; N= 250, Men (n)= 155, Women (n)= 95

Source: Canham ML, et al. Advances in Occupational Ergonomics & Safety, pp.711-4, 1998.

Characteristics and Physical Fitness of Men and Women Trainees

Variable	*Men Mean*	*Women Mean*
Age (yrs)	20.1	20.2
Height (cm)	175.2	162.0*
Weight (kg)	75.7	58.3*
BMI (wt/ht2)	24.6	22.2
Body fat (%)	16.1	26.8*
1-Mile run (min)	7.6	10.3*
2-Mile run (min)	16.4	20.3*
Sit-ups (#)	44.3	33.9*
Push-ups (#)	30.5	10.3*

*Difference between men and women significant at p <.05

Ft. Jackson, 1988;
N Women=895, N Men= 1053

Risks of Injury for Women(W) vs Men(M) by Quartiles of 2 Mile Run time

Quartile (time in min)	*nW nM*	*Risk W*	*Risk M*	*RR**	*p-value*
Q1+Q2 (<18.00)	6 96	33%	29%	1.1	0.83
Q3 (18.01-23.00)	15 34	47%	41%	1.1	0.72
Q4 (20.36-23.00)	31 21	58%	43%	1.4	0.28
Q5 (23.01+)	43 5	60%	80%	0.8	0.39

Ft. Leonard Wood, n = 251, 1996
*RR= Risk Ratio= %W/%M

Canham M et al. Advances in Occupational Ergonomics, and Safety, IOS Press, pp 711-714, 1998

MH Summary Risk Ratio= 1.1, p-value= 0.64

Gender & Risk of ≥ 1 Training-Related Injury, Controlling for Fitness, Age & Race

	Risk Factor	OR*	95% CI
Gender	Men	—	—
	Women	1.14	(0.48-2.72)
Run time	Very Fast	—	—
	Fast	1.47	(0.68-3.18)
	Average	1.54	(0.91-2.62)
	Slow	2.52	(1.26-5.04)
	Very Slow	3.23	1.59-6.58)
Strength	Very Strong	—	—
	Strong	1.41	(0.80-2.50)
	Average	1.61	(0.90-2.88)
	Weak	2.10	(0.88-5.04)
	Very Weak	2.11	(0.83-5.36)
Age (yrs)	< 20	—	—
	20-24	1.50	(1.00-2.23)
	25 +	1.26	(0.69-2.31)

* Multivariate logistic regression; other variables include SU, PU, Race

Source: Bell NS, et al. Am J Prev Med. 18(3S):141-6, 2000.

Evidence for Prevention of Weight-Bearing PA-Related Injuries

Army BCT Injury Prevention 2003 TRADOC* Program Implementation

- **New Standardized** policies & programs for PT implemented to prevent overtraining;
  - Reduced miles run during 9 weeks of BCT
  - Conducted distance runs by ability groups (fittest ability group 37 miles total; least fit 24 miles)
  - Add speed drills (4 to 5 miles total)
  - Balanced PT program (e.g., substitute grass drills for running)
- Created Injury Advisory Committees
- Monitored injury rates and PT test scores

*TRADOC = Training and Doctrine Command
**Total weight-bearing (run + march) = 435 miles

Effect of Standardized vs. Traditional PT Programs on Male Trainees, Ft Jackson, 2003

	Traditional PT*	Standardized New PT*	Rate Ratio (95% CI)
Injury Rate (n/100)	31.3%	21.8%	1.4[a] (1.1-1.7)
APFT % Passing	84.4%	88.4%	0.9[b] (0.8-1.0)
% Attrition	7.0%	6.0%	1.2[c] (0.7-1.6)

[a] p-value: Injured Traditional/Standardized<0.001;

[b] p-value: % Pass APFT Traditional/Standardized = .05;

[c] p-value % Attrition Traditional/Standardized = 0.48

Traditional PT N=656; Standardized PT N=518; Note: Avg final 2 mile run times: Trad men = 14.9 mins, Stand men = 14.8; Trad women = 18.0, Stand women = 17.8 mins.

Sources: Knapik JJ, et al. USACHPPM Report No. 12-HF-5772B-04.

And Knapik JJ, et al J. Strength Cond Res 19 (2): 246-253, 2005

Modifications of PT to Prevent Overtraining Training and Injuries

Confirmatory Studies

- Bullock SH et al AJPM 38: S156-S181, 2010 (Systematic Review)
- Knapik JJ et al J Strength Cond Res 19: 246-253, 2005
- Knapik JJ et al. Int J Sports Med 24: 372-81, 2003
- Knapik JJ et al. Injury Prevention 10:37-42, 2004
- Rudzki SJ et al. Milit Med 164: 648-652, 1999
- Shaffer RA et al. ACSM 1996

FLAT (LOW) ARCH

If you see almost your entire footprint, you have a flat arch, which means you're probably an overpronator. That is, a microsecond after footstrike, your arch collapses inward too much, resulting in excessive foot motion and increasing your risk of injuries. You need either stability shoes, which employ supportive midsole "posts" to reduce pronation and are best for mild to moderate overpronators, or motion-control shoes, which have firmer support devices and are best for severe overpronators, as well as tall, heavy (more than 185 pounds for men, 160 for women), or knock-kneed runners.

NORMAL (MEDIUM) ARCH

If you see about half of your arch, you have the most common foot type and are likely a normal pronator. Contrary to popular belief, pronation is a good thing. When the arch collapses and the ankle rolls inward, this "pronation" absorbs shock. As a normal pronator, you can wear just about any shoe, but may be best suited to a stability shoe that provides moderate arch support (or medial stability). Lightweight runners with normal arches may prefer neutral-cushioned shoes without any added support, or even a performance-training shoe that offers some support but less heft for a faster feel.

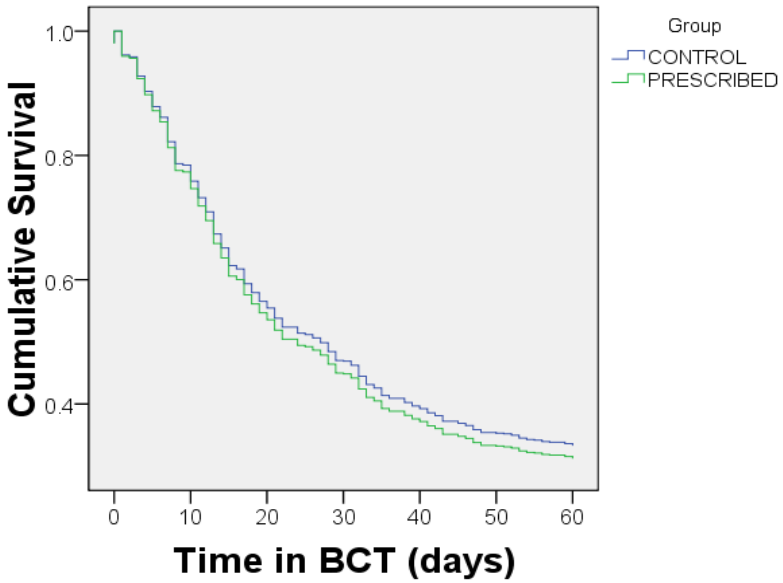
HIGH ARCH

If you see just your heel, the ball of your foot, and a thin line on the outside of your foot, you have a high arch, the least common foot type. This means you're likely an underpronator, or supinator, which can result in too much shock traveling through your body, since your arch doesn't collapse enough to absorb it. Underpronators are best suited to neutral-cushioned shoes because they need a softer midsole to encourage pronation. It's vital that an underpronator's shoes have no added stability devices to reduce or control pronation, the way a stability or motion-control shoe would.

ILLUSTRATIONS BY CHARLIE LAYTON

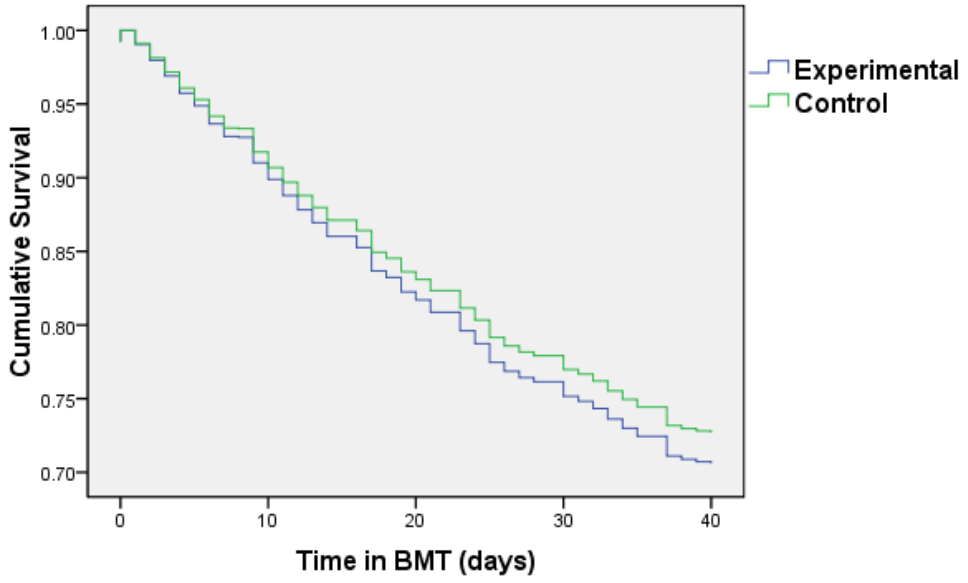
Effect on Injuries of Assigning Shoes Based on Foot Arch Height

Army: Injuries in Control and Prescribed Group Men



HR (Prescribed/Control)=1.02, 95%CI=0.89-1.17

Air Force: Injuries in Control and Experimental Group Men



HR (Exp/Contol)=1.09, 95%CI=0.92-1.29

Knapik et al., J Strength Condit Res 23:1353, 2009
Knapik et al., Am J Prev Med 38(Suppl 1):197, 2010

Other Prevention Strategies

- **Stretching** - not protective against injuries associated with weight-bearing training (Systematic Reviews: Bullock SH AJPM 2010; Herbert RD BMJ 2002; Shrier I, Clin J Sport Med 1999; Thacker SB, MSSE 2004; Small K et al Res Sports Med 2008)
- **Warm-ups** - not enough evidence to draw conclusions (Fradkin AJ, J Sci Med Sport 2006)
- **Shock absorbent insoles and orthotics** – mixed evidence but leans towards non-protective (Systematic Reviews: Cochrane Database – Rome K 2005;D'hondt NE 2002/2005; Yeung EW 2001; Other Systematic Review: Barton CJ et al Sports Med 2010; Jones BH Epi Reviews 2002; Randomized trial: Withnall R, J R Soc Med 2006)

Other Prevention Strategies

- PA-related injury prevention strategies needing further research
  - Functional movement screening (FMS) and associated exercise prescriptions.
  - Minimalist shoes (including five-toed shoe)
  - Barefoot running

Summary of Key Conclusions

Causes

- PA causes injuries and greater amounts increase risks
- Thresholds exist above which more activity increases injury risk but not fitness

Modifiable Risk Factors

- More past activity and higher fitness levels protect against injuries
- Men and women of similar fitness levels doing the same amounts of PA will have similar injury risks
- Subsets of the population exhibit greater but modifiable risks (e.g., lean-low fit, previously injured, amenorrheic, inactive, and smokers among others)

Prevention

- Prevention of overtraining can reduce injury risk and improve fitness

Conclusion

Paradigm: physical training causes injuries and greater amounts of training cause more injuries, so modifications of training to prevent overtraining are most likely to prevent injuries.

- Application of general principles from the paradigm should help maximize benefits and minimize risks of physical activity.

Contact

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