Extreme Conditioning Programs and Injury Risk in a U.S. Army Brigade Combat Team

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Unclassified

Background

Extreme Conditioning Programs (ECPs):

• Characterized by high-volume aggressive training workouts that use a variety of high-intensity exercise repetitions and short rest periods between sets.

•Examples of some ECPs: Crossfit, P90X, Insanity, and PT Pyramid

• Positive Characteristics: Exciting, challenging, motivating, and meet a broad range of in-theater real world physical activities and demands

•Negative Characteristics: Can be very competitive when performed in group settings; inadequate rest intervals between sets can lead to earlier fatigue and result in possible overuse or overtraining.

* Bergeron, M et al Current Sports Medicine Reports 2011

Background: Crossfit-Based High Intensity Power Training Improves Maximal Aerobic Fitness and Body Composition

- **Smith, M et al. (2013)**

- **Purpose:** To determine if a high intensity power training (HIPT) program could improve VO2 max and body composition

- **Subjects:** Men (23) and women (20) of various body composition and aerobic fitness levels

- **Methods:** Measure VO2 max and body composition before and after the 10 week HIPT program

- **Results:** VO2 max for men 43.1 to 48.9 ml/kg/min, for women 35.9 to 40.2 ml/kg/min. Body composition for men 22.2 to 18.0%, for women 26.6 to 23.2%

- **Conclusion:** HIPT improved both VO2 max and body composition for both genders and across all levels of fitness

* Smith, M et al. Journal of Strength and Conditioning Research 2013

Background: Crossfit in Command and General Staff College Volunteers

•**Paine, Jeffery et al. (2010)**

• **Purpose:** To measure the change in physical fitness after 8 weeks of physical training utilizing the Crossfit program.

•**Subjects:** Men (9) and women (5) from the Command and General Staff College Class

•**Methods:** Subjects completed initial and follow-up assessments consisting of 3 Crossfit workouts and the Army Physical Fitness Test.

•**Results:** All subjects increased their work output by an average of 20%

• **Conclusion:** It was concluded that the program was successful in increasing every Soldier's general fitness level and that generalized training can prepare Soldiers/athletes for unknown and known events.

* Paine, Jeffery et al. Technical Report 2010

Purpose

The purpose of this project was to examine physical training, fitness, and injury rates and to identify injury risk factors in a light infantry brigade beginning a new physical training program incorporating extreme conditioning program (ECP) elements.

Pictures from http://www.defenseimagery.mil

Example of Some of the ECP Program Elements

- Plyometrics
- High intensity water exercises
- Wrestling
- Ladder and cone agility drills
- Tire flipping
- Speed interval training
- Cinderblock throwing
- Obstacle Course

Pictures from http://www.defenseimagery.mil

Methods

- **Population:** Light infantry brigade combat team

- **Survey Data Collected:**
  - Demographic Data
  - Unit Physical Training
  - Personal Physical Training
  - Physical Fitness (APFT)
  - Tobacco Use
  - Injuries

- **Armed Forces Health Surveillance Data:**
  - Demographic Data
  - Medical Record Injuries

- **Data Analysis:**
  - Multivariate Logistic Regression

Picture from http://www.defenseimagery.mil

Results

- **Surveys administered: 1393**
- **1032 Soldiers reported participating in the new program**
- **340 Soldiers did not participate in the program**
- **21 Soldiers undetermined**
- **Demographics:**

	Men (1248)	Women (145)
Age	26.6 ± 5.8	26.3 ± 5.9
BMI	26.1 ± 3.4	24.5 ± 3.0
Smokers (Cig)	46%	32%

Pictures from http://www.defenseimagery.mil

Results: Injuries

Comparison of injury incidence before and after the implementation of a new fitness program incorporating ECPs (n=1032)

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	% Change	p-value (McNemar Test)
Overall	41%	46%	+12%	0.02
Overuse	32%	37%	+16%	0.02
Traumatic	19%	18%	-5%	0.95

Comparison of injury incidence before and after the implementation of a new fitness program incorporating ECPs on all Soldiers who did not participate in this program (n=340)

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	% Change	p-value (McNemar Test)
Overall	50%	57%	+14%	0.05
Overuse	42%	46%	+10%	0.28
Traumatic	22%	23%	+5%	1.00

Results: Top 3 Types and Causes of Injury by Group

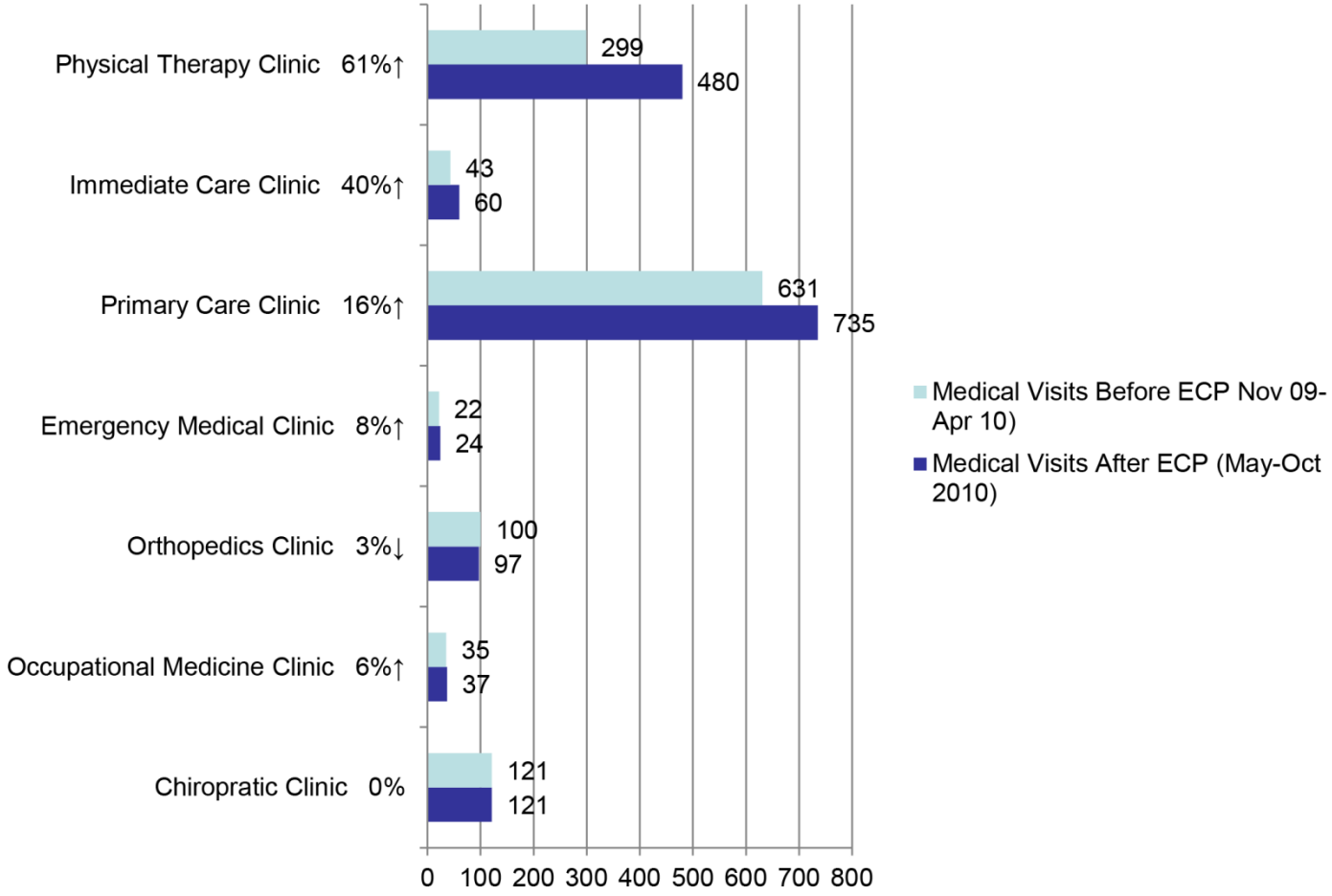
The top 3 types of injury for each group

Injury Type	ECP Group	No ECP's
Sprain/Strain	51%	44%
Broken Bones/Fracture	11%	11%
Pain	7%	6%

The top 3 causes of injury for each group

Injury Type	ECP Group	No ECP's
Running	26%	32%
Exercising	17%	13%
Walk/Hike/Road March	17%	13%

Results: Medical Visits for Those in the ECP Group



Results: Personal Characteristics and Injury Risk for ECP Group

Personal Characteristics and Risk Factors for Injury among Men Participating in a new physical training program incorporating ECPs (Women excluded except for comparison by gender)

Variable	Subcategory of Variable	N	%Injury (After)	Risk Ratio (95%CI) (After)	p-value
Gender	Men	950	45%	1.00	
	Women	82	60%	**1.34 (1.11-1.63)**	**<0.01**
Age	<24	306	44%	1.09 (0.88-1.38)	0.43
	24-25	185	46%	1.15 (0.91-1.45)	0.23
	26-29	203	40%	1.00	
	30+	240	48%	1.21 (0.98-1.50)	0.08
BMI	<25	341	37%	1.00	
	25-29	464	47%	**1.27 (1.07-1.51)**	**<0.01**
	30+	115	60%	**1.61 (1.31-1.98)**	**<0.01**
Current Smoking Status	Non-Smoker	470	39%	1.00	
	Smoker	443	51%	**1.32 (1.14-1.53)**	**<0.01**
Smokeless Status	Non-Smokeless	655	43%	1.00	
	Smokeless User	295	49%	1.15 (0.99-1.33)	0.07
Battalion	Infantry A	394	38%	1.00	
	Infantry B	116	52%	**1.38 (1.11-1.71)**	**<0.01**
	Calvary	136	52%	**1.37 (1.11-1.69)**	**<0.01**
	Field Artillery	163	42%	1.13 (0.90-1.40)	0.30
	Brigade Support Battalion	84	60%	**1.59 (1.28-1.97)**	**<0.01**
	Brigade Special Troops Battalion	57	46%	1.21 (0.89-1.66)	0.24

Results: Multivariate Analysis

Unit PT and Personal Risk Factors for Injury among Men Participating in ECPs using Multivariate Logistic Regression

Variable	Subcategory of Variable	N	Odds Ratio (95%CI)	p-value
BMI	<25	310	1.00	
	25-29.9	414	**1.77 (1.29-2.44)**	**<0.01**
	30+	98	**2.72 (1.67-4.43)**	**<0.01**
Tobacco	Non-Smoker	430	1.00	
	Smoker	392	**1.80 (1.34-2.42)**	**<0.01**
Battalion	Infantry A	342	1.00	
	Infantry B	100	**1.62 (1.01-2.61)**	**0.05**
	Calvary	128	**1.87 (1.20-2.92)**	**<0.01**
	Field Artillery	139	1.36 (0.89-2.08)	0.15
	Brigade Support Battalion	64	**1.96 (1.09-3.54)**	**0.03**
	Brigade Special Troops Battalion	49	1.20 (0.62-2.32)	0.60
Times per week performing Resistance Training with their Unit	No Resistance Training	80	1.00	
	< 1 time per week	218	**0.53 (0.31-0.92)**	**0.03**
	1-2 times per week	409	**0.50 (0.29-0.84)**	**0.01**
	≥ 3 times per week	115	**0.45 (0.24-0.85)**	**0.01**
Estimated Miles per week of running during Unit PT	≤ 7 miles a week	401	1.00	
	7.01-9.00 miles a week	54	1.05 (0.57-1.94)	0.87
	9.01- 16 miles a week	290	1.00 (0.72-1.40)	0.99
	> 16 miles a week	77	**2.24 (1.33-3.80)**	**<0.01**

Variables entered into the model: Age, BMI, Current smoking status, Battalion, How often do you participate in unit PT, Estimated total miles per week ran, Resistance training, and Agility training

Results: Multivariate Analysis

Physical Fitness Test Risk Factors for Injury among Men Participating in ECPs using Multivariate Cox Regression

Variable	Level of Variable	N	Odds Ratio (95%CI)	p-value
Push-Ups	20-56 reps	188	1.01 (0.62-1.63)	0.97
	57-67 reps	207	1.11 (0.71-1.72)	0.5
	68-76 reps	218	1.00 (0.66-1.50)	0.99
	77-111 reps	222	1.00	
Sit-Ups	19-61 reps	199	1.53 (0.94-2.50)	0.09
	62-69 reps	205	1.03 (0.66-1.60)	0.91
	70-78 reps	213	0.92 (0.60-1.39)	0.68
	79-109 reps	218	1.00	
2 Mile Run (minutes and Fraction of a minute)	11.12-13.52 min	226	1.00	
	13.53-14.50 min	217	1.42 (0.95-2.12)	0.09
	14.51-15.50 min	195	1.45 (0.95-220)	0.08
	≥ 15.51 min	197	**1.76 (1.13-2.74)**	**0.01**

Variables entered into the model: Age, Battalion, Push-ups, Sit-ups and 2 mile run

* Controlled for age and battalion

Discussion: BMI

- Injury risk for men was higher for those with a BMI classifying them as overweight or obese.
- Previous literature has shown that Soldiers with a higher BMI are at a greater risk of being injured. Reynolds K, 1994, 2009, and Knapik J (2007)
- In the current study 62% of the men were considered either overweight or obese, which is similar to the United States population where 64% of men between the ages of 20 to 39 are also considered either overweight or obese
- According to CDC, BMI is a good indicator of body fatness for population based assessments

Discussion: BMI

- In a study by Crawford et al. (2011), Soldiers with ≤ 18% body fat performed significantly better on 7 of 10 fitness tests, compared to Soldiers with a body fat of > 18%.

- Bohnker et al. (2005) examined mean BMI and overall physical readiness test scores (Outstanding, Excellent, Good, Satisfactory and Fail). As physical fitness test scores decreased, mean BMI increased for both men and women.

Pictures from http://www.defenseimagery.mil

Discussion: BMI

- Similar to Bohnker et al. (2005) a trend between BMI and fitness was also observed in the current study (analysis performed on all men who completed the survey and had injury data). Soldiers with lower physical fitness test results also had higher average BMIs

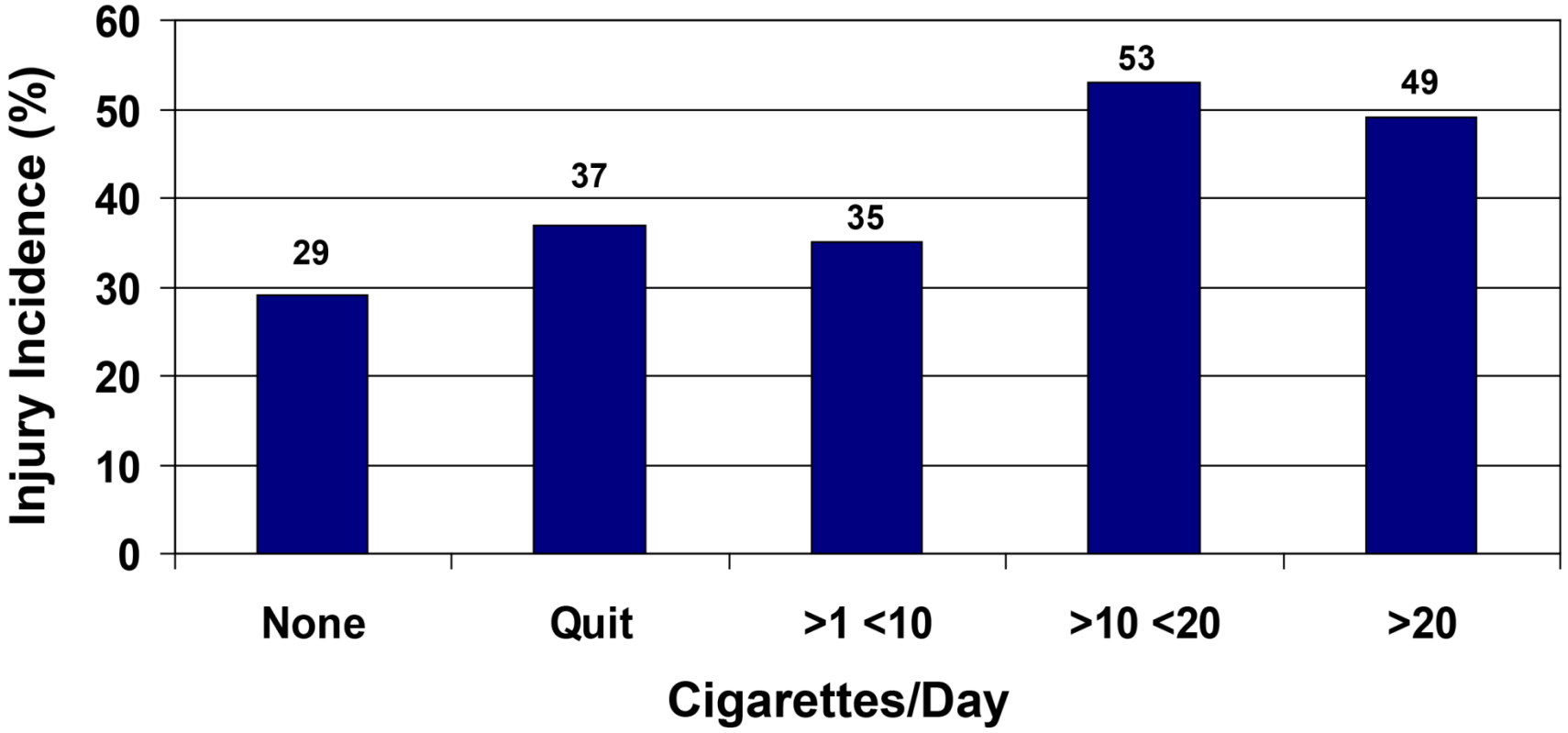
Mean BMIs and Physical Fitness Test Scores Grouped by Quartiles of Poor to High Performance for Men

Mean BMIs for Fitness Variables	n	Q1 (low performance)	Q2	Q3	Q4 (High performance)	ANOVA p-value
2 Mile Run (Mean BMI)	1091	28.2 BMI	26.1 BMI	25.2 BMI	24.6 BMI	<0.01
Push-Ups (Mean BMI)	1137	26.6 BMI	26.1 BMI	26.1 BMI	25.8 BMI	0.03
Sit-Ups (Mean BMI)	1134	27.0 BMI	26.1 BMI	25.7 BMI	25.5 BMI	<0.01

Discussion: Tobacco Use

- Injury risk was higher in smokers than nonsmokers
- Previous studies have also demonstrated an increased risk of injury in smokers compared to nonsmokers, the number of cigarettes smoked per day, and risk of musculoskeletal injury. (Reynolds K, 1994, 1996), (Knapik J, 2001, 2006, 2009), (Heir T, 1997), (Altarac M, 2000), (Munnoch K, 2007), (Dettori J, 1996) and (Grier, T 2010)
- The relationship between tobacco use and injury may be due to a compromised ability to repair damaged tissues, thereby increasing susceptibility to the repetitive microtrauma that presumably causes overuse injuries. (Amoroso P, 1996)

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

Discussion: Battalions

- Infantry A had the lowest risk of injury incidence after the implementation of ECPs.
  - Youngest Soldiers
  - One of the lowest average BMI's
  - Performed less running per week during Unit PT
  - Performed the most sprint, resistance and agility training per week when compared to the other battalions.

- Infantry A had an injury surveillance tracking system and reported these metrics every three weeks.

Discussion: Resistance Training

- Soldiers performing resistance training once a week were at a lower risk of injury than Soldiers in units that did not perform resistance training.

- In a U.S. Air Force study, Walker et al. (2010) replaced traditional long distance running with interval running, agility training and functional strength training. Results: Overall injuries decreased by 67% and trainees scored higher on nearly all of the fitness measures.

- In a Meta-Analysis by Wilson et al. (2012) both strength training and concurrent training (combination of strength and endurance training) had larger effect sizes on strength, 1.76 (95% Confidence Interval (CI) 1.34-2.18) and 1.44 (95%CI 1.03-1.84) respectively, when compared to just endurance training (0.78, 95%CI 0.36-1.19)

Pull-Ups – Men (Reps)

Pull-Ups (Reps)	n	% Injured	Risk Ratio (95%CI)	p-value
≤ 2	339	48%	1.29 (1.08-1.54)	<0.01
3-5	479	46%	1.24 (1.05-1.46)	0.01
6-9	464	44%	1.19 (1.00-1.41)	0.04
10+	372	37%	1.00	

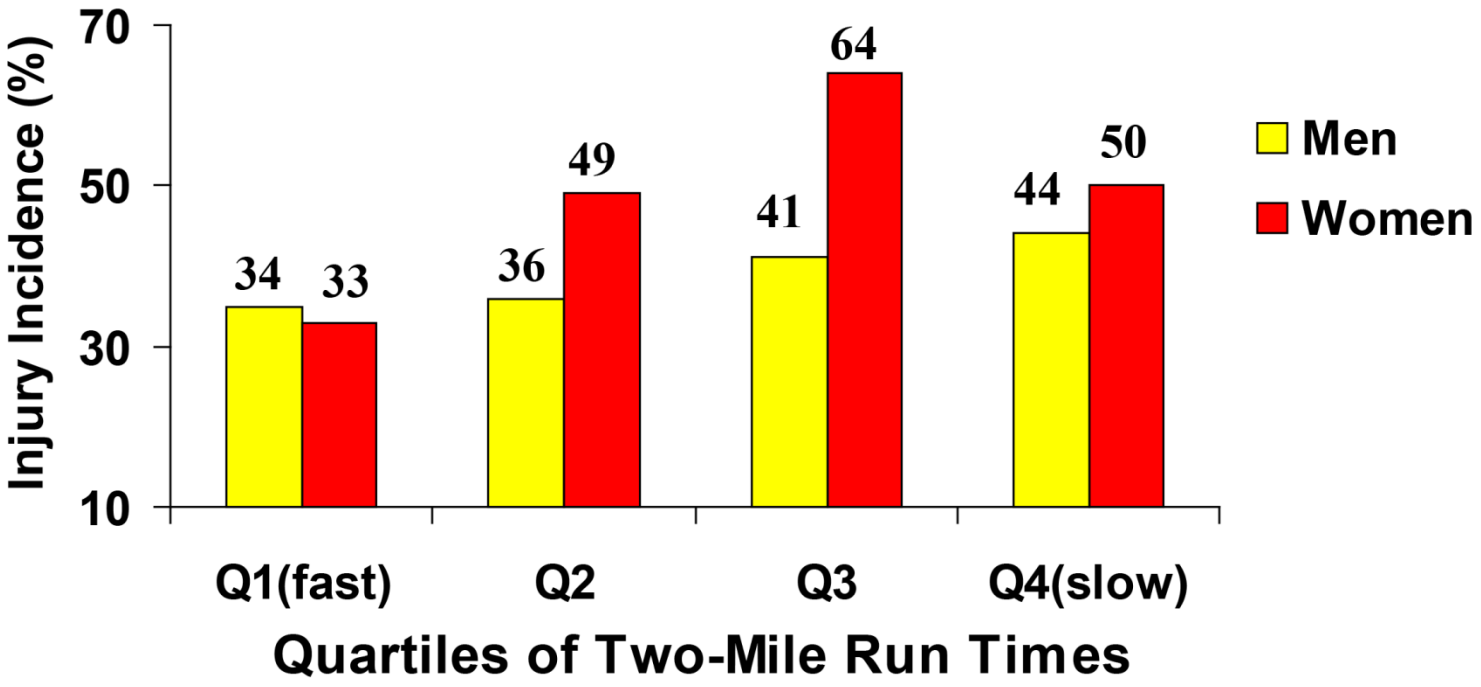
Chi Square for Linear Trend <0.01

Source: Grier T, Chervak M, Unpublished Data from the 4 ID

Discussion: APFT 2 Mile Run

- Injury risk for the slowest 2-mile run times was higher when compared to the fastest 2-mile run times.
- Previous studies investigating run times during basic combat training have also found that slower run times place Soldiers at a higher risk of injury. (Knapik J, 1993, 2001, 2008), (Jones BH, 1993), and (Hauret K, 2004)
- Soldiers with lower aerobic capacities will likely experience greater physiological stress and/or fatigue during tasks (such as running, cross-training and calisthenics) due to exercising at a higher percentage of their maximum aerobic capacity when compared to Soldiers with greater fitness levels.

Association of Two-Mile Run Time and Injuries in the Operational Army



N=2002 Men, 171 Women; Risk Ratio(Q4/Q1):Men=1.3, Women=1.5

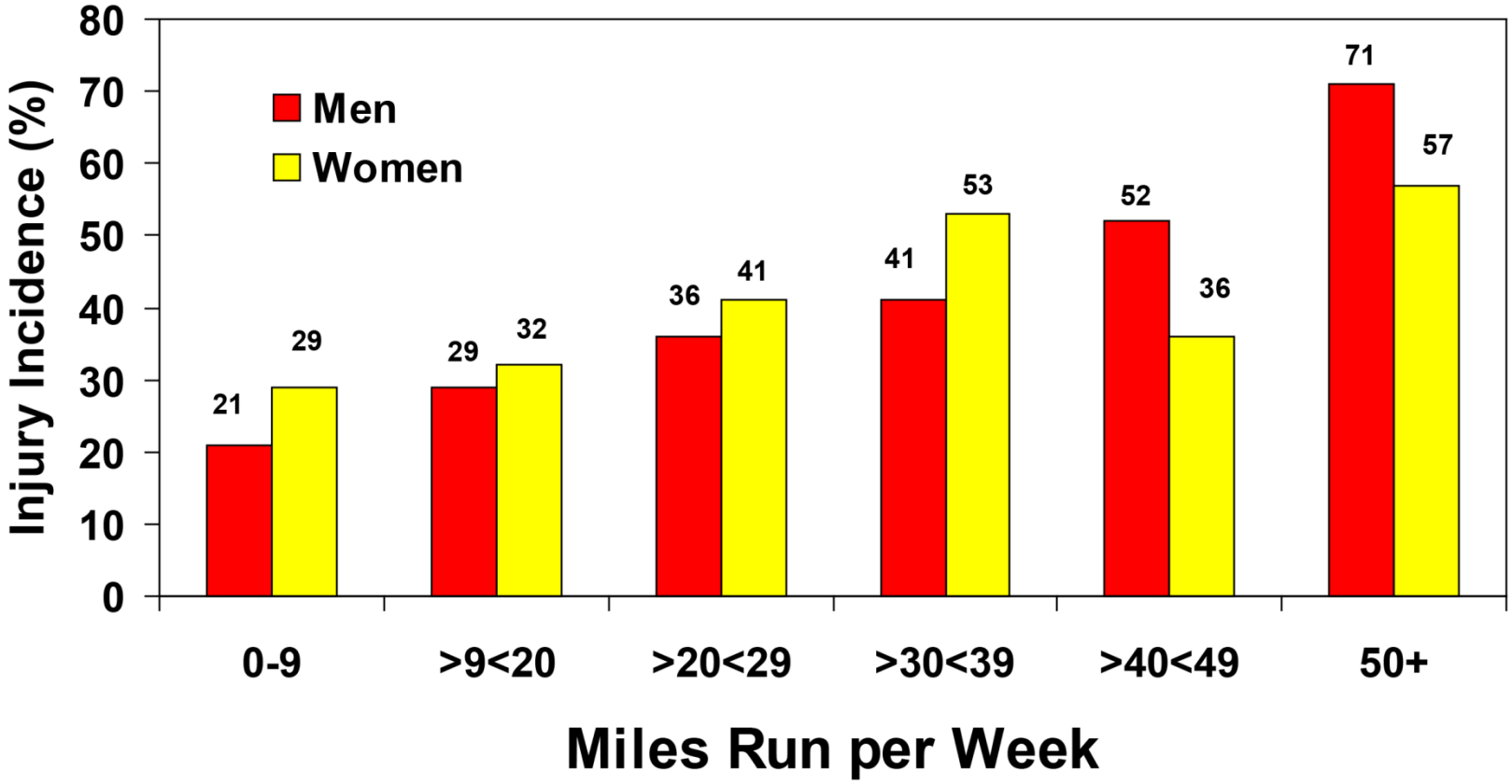
p-value for trend: Men ≤ 0.01, Women = 0.06

Source: Grier T, Chervak M, Unpublished Data from the 4 ID

Discussion: Running Miles per Week

- Soldiers who ran greater distances during unit PT were at a higher risk of injury.
- Other studies have also shown that risk of injury increases with miles run per week. (Koplan J, 1982), (Marti B, 1984), and (Samet J, 1982)
- Analysis of APFT scores indicated those who ran greater distances per week (16 + miles) had an average 2-mile run time of 14.6 minutes (± 1.51 minutes), and those who ran less miles per week (< 16 miles per week) had identical average 2-mile run time of 14.6 minutes (±1.61 minutes).

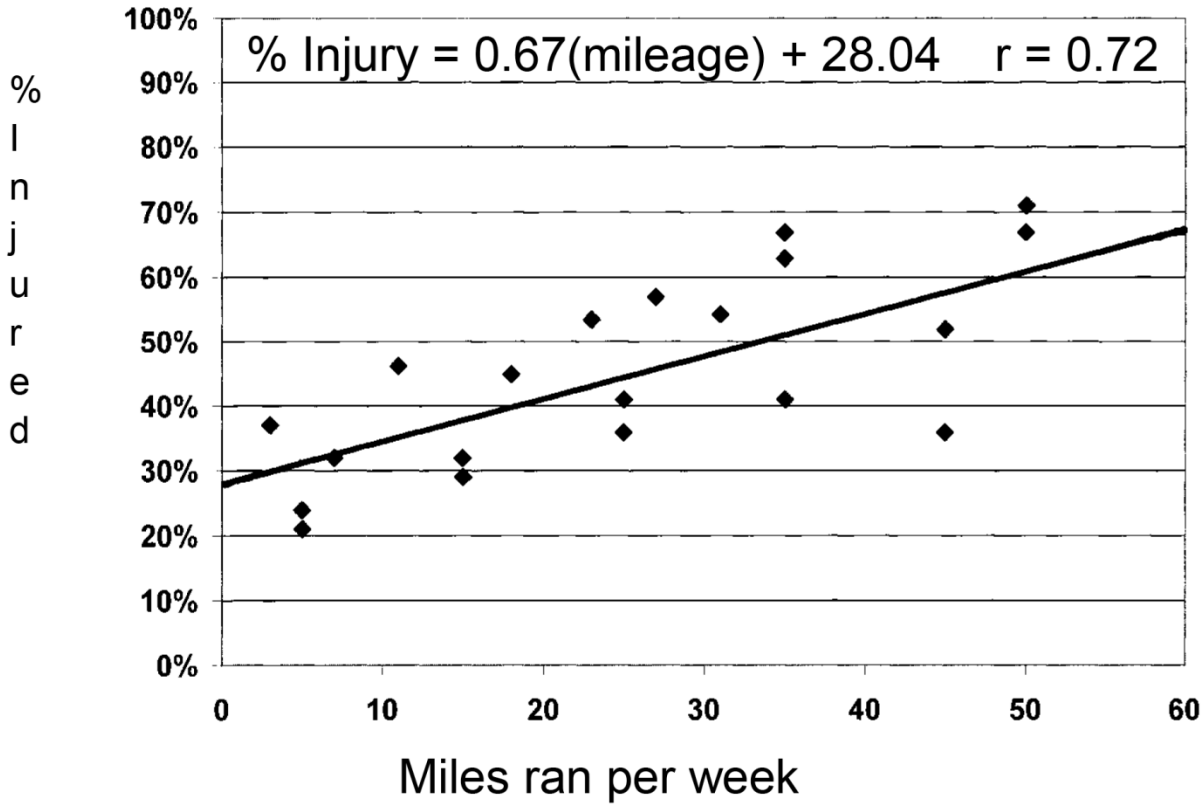
Injuries per Year among Men and Women by Miles Run per Week



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

Discussion: Injury Incidence and Miles Ran per Week

Miles per week and % injuries of those who did and did not seek medical consultation for their injuries (Data from Koplan, Marti and Samet)



Conclusion

- This project found similar increases in injury rates for units performing ECPs and units not performing ECPs. Therefore no recommendations can be made for or against ECPs.

- Risk factors associated with higher risk of injury following the start of a new exercise program incorporating ECPs included:
  - running longer distances during unit physical training
  - having a BMI ≥ 25
  - smoking cigarettes

- A lower risk of injury or protective effect was found for Soldiers who performed any resistance training compared to Soldiers who performed no resistance training during unit PT.

- Soldiers should approach ECPs or exercise programs with ECP components with discretion and recognize their challenges and limitations. The goal of all fitness programs should be to meet occupational and operational demands and expectations while minimizing injury risks.

- Army Public Health Notice on ECPs: http://www.army.mil/standto/archive/issue.php?issue=2012-07-02

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