Extreme Conditioning Programs and Injury Risk in a US Army Brigade Combat Team

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ABSTRACT

Context: Brigades and battalions throughout the US Army are currently implementing a variety of exercise and conditioning programs with greater focus on preparation for mission-specific tasks. An Army physical therapy clinic working with a light infantry brigade developed the Advanced Tactical Athlete Conditioning (ATAC) program. The ATAC program is a unique physical training program consisting of high-intensity aquatic exercises, tactical agility circuits, combat core conditioning, and interval speed training. Along with ATAC, battalions have also incorporated components of fitness programs such as the Ranger Athlete Warrior program and CrossFit (Crossfit, Inc, Santa Monica, CA) an extreme conditioning program (ECP).

Objective: To determine if these new programs (ATAC, ECP) had an effect on injury rates and physical fitness.

Design: Surveys were administered to collect personal characteristics, tobacco use, personal physical fitness training, Army physical fitness test results, and self-reported injuries. Medical record injury data were obtained 6 months before and 6 months after the implementation of the new program. Predictors of injury risk were assessed using multivariate logistic regression. Odds ratios (OR) and 95% confidence intervals (CI) were reported.

Results: Injury incidence among Soldiers increased 12% for overall injuries and 16% for overuse injuries after the implementation of the ATAC/ECPs. However, injury incidence among Soldiers not participating in ATAC/ECPs also increased 14% for overall injuries and 10% for overuse injuries. Risk factors associated with higher injury risk for Soldiers participating in ATAC/ECPs included:

greater mileage run per week during unit physical training (OR (>16 miles per week÷≤7 miles per week)=2.24, 95% CI, 1.33-3.80)

higher body mass index (BMI) (OR (BMI 25-29.9÷BMI<25)=1.77, 95% CI, 1.29-2.44), (OR (BMI ≥30÷BMI<25)=2.72, 95% CI, 1.67-4.43)

cigarette use (OR (smoker÷nonsmoker)=1.80, 95% CI, 1.34-2.42)

poor performance on the 2-mile run during the Army Physical Fitness Test (APFT) (OR (≥15.51 minutes÷≤13.52 minutes)=1.76, 95% CI, 1.13-2.74)

Injury risk was lower for those reporting resistance training

(OR (<1 time per week÷none)=0.53, 95% CI, 0.31-0.92)

(OR (1-2 times per week÷none)=0.50, 95% CI, 0.29-0.84)

(OR (≥3 times per week÷none)=0.45, 95% CI, 0.24-0.85)

Conclusions: Given that Soldiers participating in ATAC/ECPs showed similar changes in injury rates compared to Soldiers not participating in ATAC/ECPs, no recommendation can be made for or against implementation of ATAC/ECPs.

Soldiers must maintain high levels of physical fitness to endure demanding tasks, harsh deployment environments and military occupational specialty requirements. However, routine training required to maintain high levels of physical fitness can result in musculoskeletal injuries, limited duty days, and significant health care costs.[1-3] Studies have shown that injuries related to physical training (PT) account for 30% to 50% of all injuries in US Army Soldiers.[4-6] An investigation examining injury incidence in light infantry Soldiers found that physical training caused 50% of all injuries, and 30% of these injuries were associated with running.[4] Injuries caused approximately 10 times the number of limited duty days compared to illness. The investigators concluded that physical training is associated with a high number of injuries in infantry Soldiers.[4] It has also been

shown that musculoskeletal injuries are a leading cause of hospitalization.[7] In a study investigating hospitalizations for sports and Army physical training injuries, 11% of 120,430 hospital admissions over a 6-year period were attributed to sports or Army physical training injuries. This resulted in 29,435 total lost duty days, with an average of 13 days of limited duty per injury for male Soldiers and 11 days per injury for female Soldiers.[3] These investigations indicate that physical training-related injuries have a considerable impact on the health and readiness of Soldiers.

Previous research has identified a number of risk factors for injury in infantry Soldiers. In one study, higher risk of injury was associated with fewer sit-ups on the Army Physical Fitness Test (APFT) and slower 2-mile run times,[8] while another study showed higher risk of injury was associated with smoking and a body mass index (BMI) of 25 or more.[9] In an investigation of British infantry Soldiers, higher risk of injury was associated with younger age, previous lower limb injury, and previous back injury.[10] More work to identify the most important risk factors among infantry Soldiers is needed.

Only a few investigations have explored injury risk during the implementation of a new military fitness program.[11-15] In 3 investigations, Knapik et al compared Soldiers performing Army Physical Readiness Training (PRT) to Soldiers performing traditional Army physical training. Physical readiness training consists of calisthenics, movement drills, climbing drills, dumbbell exercises, interval training, and ability group long-distance running whereas traditional Army physical training consists primarily of warm-up and stretching exercises followed by calisthenics, push-ups, sit-ups, some sprint training, and group long-distance running. For all 3 studies, the adjusted risk of injury was 1.5 to 1.8 times higher in the groups performing traditional physical training compared to those performing PRT. It was also found that scores on the APFT were higher or similar for groups using the PRT program. Knapik et al concluded that the PRT program results in fewer injuries and equal or greater improvements in fitness and military performance compared to traditional Army physical training.[11-13,16]

In a US Air Force study, a new PT program implemented within the combat controller training pipeline was evaluated. The goal of this new PT program was to reduce overuse and overtraining injuries and transition from a traditional PT program to a functional PT program. For the new PT program, running mileage decreased by 50%, and long-distance runs were replaced with interval running and agility training. In addition, bodybuilding type resistance training (single joint) was replaced with functional strength training movements (multiple joint, standing exercises), and an athletic trainer was hired to visit the group twice per week. Investigators found that by replacing traditional training with the new functional training program, overall injuries decreased by 67%, and improvements were made in body composition, aerobic capacity, ventilatory threshold, upper body power, and graduation rates. The authors concluded that the new fitness program decreased injury rates, increased fitness performance and graduation rates, and suggested that other combat athletes would benefit from adopting these practices.[14]

A variety of exercise and conditioning programs with greater focus on preparation for mission-specific tasks are currently being implemented by various brigades and battalions throughout the US Army. As a result, Soldiers are transitioning from traditional Army PT to a more intensive, combat-focused PT program. Injury rates and risk factors associated with these programs are not well known. 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 PT program incorporating elements of extreme conditioning programs (ECPs).

METHOD

Population

The population consisted of Soldiers in a light infantry brigade combat team (N=1,393). The brigade combat team consisted of 2 infantry battalions, a cavalry battalion, a field artillery battalion, a brigade support battalion (hereinafter referred to as Infantry A, Infantry B, Cavalry, Field Artillery, and Brigade Support), and a brigade special troops battalion. Rosters of unit members were requested and obtained through the brigade medical officer. Roster information included each Soldier's battalion.

Surveys

A survey was used to collect information from Soldiers about personal characteristics, tobacco use, unit and personal physical fitness training, Army physical fitness test results, and injuries. The survey was administered in September 2010, approximately 4 months after the new physical fitness and conditioning programs began.

Interviews

Battalion commanders were interviewed to obtain their views and opinions on physical training and fitness. They were also asked about training equipment and injury prevention.

Exercise Instructor Certification and Programs Conducted by the Brigade Combat Team

Selected Soldiers from every battalion in the brigade combat team attended a 1-week certification class on the fundamentals of the Advanced Tactical Athlete Conditioning (ATAC) program. The ATAC Program consisted of workouts employing plyometrics, kettlebells, medicine balls, high-intensity water exercises, wrestling, ladder and cone agility drills, tire flipping, speed interval training, and cinderblock throwing. Some of the battalions also required their Soldiers to attend additional certification classes in exercise and fitness performance involving other exercise programs such as CrossFit (CrossFit Inc, Washington, DC) and the Ranger Athlete Warrior program (RAW), developed within the US Army's 25th Infantry Division.

CrossFit is a core strength and conditioning program that aims to prepare athletes for any physical contingency. CrossFit consists of continuously varied, high-intensity functional movements that generally fall into 3 categories: gymnastics, Olympic weightlifting, and metabolic conditioning or "cardio."* There are 4 components to the RAW program: functional fitness, performance nutrition, sports medicine, and mental toughness. The functional fitness component of RAW consists of movement drills (before each PT session), muscular endurance workouts, heavy resistance workouts, power and power endurance workouts, endurance training workouts, movement skills training, hybrid drills, and recovery exercises (at the end of each workout).†

CrossFit and RAW or parts of these exercise programs can also be classified as ECPs,[17] which are characterized by high-volume, aggressive exercise workouts with a variety of high-intensity exercise repetitions and short rest periods between sets. Popular ECPs include P90X and Insanity (Beachbody LLC, Santa Monica, CA), and Gym Jones (Gym Jones LLC, Salt Lake City, UT).

New Physical Training Program

Soldiers began a new physical training program that incorporated ATAC and components of fitness programs such as the RAW program and CrossFit.

Army Physical Fitness Test Scores

The APFT was used as a measure of physical fitness. Self-reported scores from each Soldier's most recent APFT were obtained from the surveys. Close correlations have been found between actual APFT scores and self-reported APFT scores.[18] The APFT consisted of 3 events: a 2-minute maximal effort push-up event, a 2-minute maximal effort sit-up event, and a 2-mile run performed for time. Events were performed in accordance with instructions contained in *Field Manual 7-22: Army Physical Readiness Training*.[19] Performance metrics obtained included the number of push-ups and sit-ups successfully completed within separate 2-minute time periods. The performance measure for the run was the time taken to complete a 2-mile distance.

Demographics and Injury Outcome Measures

The Armed Forces Health Surveillance Center (AFHSC) provided demographic data obtained from the Defense Manpower Data Center (DMDC). Demographics included date of birth, education level, marital status, race, and gender.

Data on injuries treated in military treatment facilities or paid for by the Military Health System (purchased care) were obtained from the Defense Medical Surveillance System (DMSS). A brigade unit roster was provided to the AFHSC, which returned DMSS data containing visit dates and International Classification of Disease 9th Revision (ICD-9)‡ diagnosis codes for all inpatient and outpatient medical encounters captured electronically by the DMSS occurring between November 1, 2009 and October 28, 2010. Injuries were categorized into 3 groups—overall injury, overuse injuries, and traumatic injuries—using the primary (first) ICD-9 diagnosis code in a manner consistent with prior studies of military training injuries.[20,21]

Overall injuries comprise all ICD-9 codes from the 800-999 and 710-739 code series related to acute and chronic musculoskeletal injuries, including environmental injuries. Overuse injuries contain a subset of musculoskeletal injuries resulting from cumulative microtrauma due to repetitive motion, typically in the 710-739 ICD-9 code series. This series indicates such diagnoses as stress fractures, stress reactions, tendonitis, bursitis, fasciitis, shin splints, and musculoskeletal pain (not otherwise specified). Traumatic injuries contain a subset of musculoskeletal injuries resulting from a strong sudden force or forces being applied to the body, including events such as a fall from a ladder, an automobile crash, or being struck by a bullet. These injuries are contained in the 800-999 ICD-9 code series.

Data Analysis

The IBM SPSS Statistics (V 18.0) application (IBM Corp, Chicago, IL) was used for statistical analysis.

*CrossFit Forging Elite Fitness – http://www.crossfit.com/cf-info/what-crossfit.html

†RAW PT Program Manual – http://www.25idl.army.mil/pt/rawptguide_bp.pdf

‡http://www.cdc.gov/nchs/icd/icd9.htm

Descriptive statistics (frequencies, distributions, means, SDs) were calculated for personal characteristics, physical training, and physical fitness. Body mass index was calculated as weight in kilograms divided by height in meters squared (kg/m²). The BMI was categorized according to the Centers for Disease Control and Prevention (CDC) classifications for normal, overweight, and obese.[22] Current cigarette smokers were identified as smoking at least 1 cigarette within the last 30 days, and smoking 100 or more cigarettes in their lifetime.

To assess changes in injury rates pre- and postimplementation of the physical training programs, the McNemar test was used to compare injury incidence among Soldiers in the 6 months before the new programs were initiated (November 2009 to April 2010) with injury incidence in the 6 months following full implementation of the program (May 2010 to October 2010) for the overall, overuse, and traumatic injury categories. For each of the 2 periods, injury risk (percentage) for each category was calculated as:

$$\frac{\text{number of Soldiers with 1 or more injuries}}{\text{total number of Soldiers}} \times 100\%$$

To investigate potential injury risk factors among Soldiers in the brigade, injury risk ratio and 95% CI, were calculated using the electronic medical record data on overall injuries occurring after the implementation of the new exercise programs. Potential injury risk factors included demographic characteristics obtained from AFHSC as well as health behavior, physical training, and physical fitness data collected by survey.

A backward-stepping multivariate logistic regression and a forced multivariate logistic regression model were used to assess key factors for association with injury risk in this population. Odds ratios and 95% CIs were calculated for each potential risk factor (independent variables).

RESULTS

The average age of Soldiers in the brigade was 26.8±5.9 years with a range of 18 to 52 years. A majority of the Soldiers were classified as overweight or obese (61%), white (62%), rank of E4 to E6 (61%), high school graduates (82%), and married (55%). The descriptive statistics are presented in Table 1.

Due to the small number of Soldiers who participated in the ATAC program (n=87), the ATAC and ECP groups were combined in further analyses, comparing Soldiers who participated in ATAC/ECPs with Soldiers who did not report participating in those programs. Using injuries recorded in the medical records, injury rates of Soldiers in units participating in ATAC/ECPs were compared to injury rates for Soldiers in units that did not participate. A total of 1,032 Soldiers reported that their units were participating in ATAC/ECPs, while the other 340 Soldiers did not report participation. Soldiers were either exercising on their own time or were performing traditional PT. The baseline overall injury rates for Soldiers participating in ATAC/ECPs and Soldiers who did not participate were 41% and 50%, respectively, as shown in Tables 2 and 3.

After full implementation of the ATAC/ECPs, injury incidence increased by 12% and 16% for overall injuries

Table 1. Descriptive Statistics for Men and Women in the Light Infantry Brigade.

Variable	Subcategory of Variable	Men M=1,248		Women W=145		Men and Women N=1,393	
		n	%M	n	%W	n	%N
Gender	Men					1,248	90%
	Women					145	10%
Age	<23	374	30%	46	32%	420	30%
	23-25	333	27%	40	28%	373	27%
	26-29	258	21%	28	19%	286	21%
	30+	283	23%	31	21%	314	23%
Body mass index	≤25 (normal)	450	37%	85	60%	535	40%
	25-29 (overweight)	593	49%	49	35%	642	48%
	30+ (obese)	161	13%	7	5%	168	13%
Rank	E1-E3	331	27%	44	30%	375	27%
	E4-E6	769	62%	86	59%	855	61%
	E7-E9	67	5%	5	3%	72	5%
	W1-W2	5	0.4%	1	0.7%	6	0.4%
	O1-O3	72	6%	9	6%	81	6%
	O4-O6	4	0.3%	0	0%	4	0.3%
Race	White	803	64%	61	42%	864	62%
	Black	186	15%	53	37%	239	17%
	Hispanic	138	11%	15	10%	153	11%
	American Indian	9	1%	2	1%	11	1%
	Asian	100	8%	13	9%	113	8%
	Unknown	12	1%	1	1%	13	1%
Education Level	No High School	6	0.5%	0	0%	6	0.4%
	High School	1,021	82%	114	79%	1,135	82%
	Some College	88	7%	12	8%	100	7%
	Bachelor's	98	8%	16	11%	114	8%
	Master's	5	0.4%	2	1%	7	0.5%
	Unknown	30	2%	1	1%	31	2%
Marital Status	Married	690	55%	76	52%	766	55%
	Single	506	41%	53	37%	559	40%
	Other	52	4%	16	11%	68	5%
Battalion	Infantry A	445	36%	15	10%	460	33%
	Infantry B	150	12%	0	0%	150	11%
	Cavalry	185	15%	11	8%	196	14%
	Field artillery	201	16%	11	8%	212	15%
	Brigade support battalion	135	11%	72	50%	207	15%
	Brigade special troops battalion	132	11%	36	25%	168	12%

and overuse injuries, respectively, for Soldiers who participated (Table 2). Injury incidence for Soldiers who did not participate increased by 14% for overall injuries and 10% for overuse injuries (Table 3). The absolute percentage change in overall injury incidence for the ATAC/ECPs and no-ATAC/ECPs groups was an increase of 5% and 7%, respectively (Tables 2 and 3).

Table 2. Comparison of Injury Incidence Before and After the Implementation of ATAC/ECPs (N=1,032).

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	Absolute Change	Change	*P* (McNemar Test)
Overall	41%	46%	+5%	+12%	.02
Overuse	32%	37%	+5%	+16%	.02
Traumatic	19%	18%	-1%	-5%	.95

ATAC indicates Advanced Tactical Athlete Conditioning program.
ECP indicates extreme conditioning program.

Table 3. Comparison of Injury Incidence Before and After the Implementation of ATAC/ECPs on all Soldiers Who did not Participate in ATAC/ECPs (N=340).

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	Absolute Change	Change	*P* (McNemar Test)
Overall	50%	57%	+7%	+14%	.05
Overuse	42%	46%	+4%	+10%	.28
Traumatic	22%	23%	1%	+5%	1.00

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ECP indicates extreme conditioning program.

Table 4. Personal Characteristics and Risk Factors for Injury Among Men Participating in ATAC/ECPs (N=1,032).

Variable	Subcategory of Variable	N	Injury After ATAC/ECP	Risk Ratio (95%CI) After ATAC/ECP	*P*
Gender	Men	950	45%	1.00	
	Women	82	60%	1.34 (1.11-1.63)	<.01
Age	<24	306	44%	1.09 (0.88-1.38)	.43
	24-25	185	46%	1.15 (0.91-1.45)	.23
	26-29	203	40%	1.00	
	30+	240	48%	1.21 (0.98-1.50)	.08
Body Mass Indexl	<25	341	37%	1.00	
	25-29	464	47%	1.27 (1.07-1.51)	<.01
	30+	115	60%	1.61 (1.31-1.98)	<.01
Current Smoking Status	Nonsmoker	470	39%	1.00	
	Smoker	443	51%	1.32 (1.14-1.53)	<.01
Smokeless Status	Nonsmokeless	655	43%	1.00	
	Smokeless User	295	49%	1.15 (0.99-1.33)	.07
Battalion	Infantry A	394	38%	1.00	
	Infantry B	116	52%	1.38 (1.11-1.71)	<.01
	Cavalry	136	52%	1.37 (1.11-1.69)	<.01
	Field artillery	163	42%	1.13 (0.90-1.40)	.30
	Brigade support battalion	84	60%	1.59 (1.28-1.97)	<.01
	Brigade special troops battalion	57	46%	1.21 (0.89-1.66)	.24

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Risk Factors for Men Participating in ATAC/ECPs

Tables 4 and 5 display the injury risk ratio variables for factors possibly associated with risk of injury. Since there were only 82 women participating in ATAC/ECPs, the following analysis excluded women, except for initial comparisons of risk by gender. The number of responses may slightly vary between questions due to missing answers on some of the surveys. Higher risk of injury was associated with female gender; overweight or obese status; current smoking; and Infantry B, Cavalry, and Brigade Support battalions. An examination of physical training risk factors determined that injury risk was higher for Soldiers who participated in unit PT less than 5 times a week and ran more than 16 miles per week. Soldiers who performed resistance and agility training had a lower risk of injury. Analysis of APFT data indicated that those with lower performances on any of the 3 elements of the physical fitness test (push-ups, sit-ups, 2-mile run) were at a higher risk of being injured.

Multivariate Analysis of Injury Risk Factors Following Implementation of ATAC/ECPs

Table 6 displays the results of a backward-stepping multivariate logistic regression analysis that examined unit PT and personal risk factors. Soldiers who were overweight, obese, used tobacco (cigarettes) and were in the Infantry B, Cavalry, or Brigade Support battalions were at a higher risk of injury. For unit PT, men who ran the greatest amount of miles per week were at a higher risk of injury, while men who performed any resistance training were at a lower risk of injury. Further analysis of total miles ran per week revealed that Soldiers who ran more than 16 miles per week during unit PT had identical 2-mile run time scores at 14.6±1.51 minutes compared to Soldiers who ran less than 16 miles per week during unit PT at 14.6±1.61 minutes.

Table 7 displays the results of a multivariate logistic regression analysis examining components of the physical fitness test controlling for age and battalion. Soldiers who performed poorly on the 2-mile run were at a higher risk of injury.

COMMENT

One of the major findings of this investigation was the increase in overall injury incidence for Soldiers who did and did not participate in this new program after its

Table 5. Physical Training and Physical Fitness Risk Factors for Injury among Men Participating in ATAC/ECPs (n=950).

Variable	Subcategory of Variable	n	Injury After ATAC/ECP	Risk Ratio (95% CI) After ATAC/ECP	*P*
Physical training at prior assignment	Traditional PT	767	46%	1.00	
	Extreme conditioning programs	47	43%	0.93 (0.66-1.31)	.67
	Combination ECP and traditional	93	39%	0.85 (0.65-1.11)	.20
	Other and/or traditional	36	39%	0.85 (0.56-1.29)	.42
How often do you participate in unit PT?	<5 times per week	109	59%	1.00	
	5-7 times per week	730	42%	0.72 (0.60-0.86)	<.01
	>7 times per week	104	45%	0.77 (0.59-1.00)	.05
Does your unit perform cross-training/ extreme conditioning programs for PT?	Extreme conditioning programs	610	45%	1.00	
	ATAC and/or combination of ATAC/ other programs	340	44%	1.00 (0.86-1.16)	.96
How many times per week do you perform cross-training/ECP?	<1 time per week	66	50%	1.00	
	1-2 times per week	400	44%	0.88 (0.67-1.15)	.36
	3-4 times per week	286	43%	0.86 (0.65-1.13)	.30
	>4 times per week	167	45%	0.90 (0.67-1.21)	.48
Estimated total miles per week ran (unit PT)	≤7 miles per week	445	39%	1.00	
	7.01-9.00 miles per week	63	48%	1.23 (0.92-1.63)	.19
	9.01- 16 miles per week	320	44%	1.14 (0.96-1.35)	.13
	>16 miles per week	81	59%	1.52 (1.23-1.89)	<.01
Times per week performed sprint training	No sprint training	15	53%	1.00	
	<1 time per week	163	45%	0.85 (0.52-1.41)	.56
	1-2 times per week	620	44%	0.82 (0.50-1.32)	.45
	≥3 times per week	146	47%	0.89 (0.54-1.47)	.65
Times per week of resistance training	No resistance training	102	59%	1.00	
	<1 time per week	254	48%	0.82 (0.66-1.00)	.07
	1-2 times per week	458	41%	0.69 (0.57-0.84)	<.01
	≥3 times per week	130	41%	0.69 (0.53-0.90)	<.01
Times per week of agility drills	No agility training	110	58%	1.00	
	<1 time per week	297	45%	0.78 (0.63-0.95)	<.02
	1-2 times per week	431	42%	0.72 (0.59-0.87)	<.01
	≥3 times per week	106	41%	0.70 (0.53-0.92)	<.01
How often performed road marches	No road marching	29	41%	1.00	
	<1 time per month	134	55%	1.32 (0.83-2.09)	.20
	1 time per month	148	41%	0.98 (0.61-1.58)	.93
	2 times per month	237	48%	1.15 (0.73-1.81)	.52
	3 times per month	150	37%	0.89 (0.55-1.43)	.63
	>3 times per month	230	44%	1.05 (0.66-1.66)	.83
Push-ups	20-56 repetitions	208	47%	1.21 (0.97-1.50)	.09
	57-67 repetitions	221	48%	1.23 (0.99-1.52)	.06
	68-76 repetitions	230	41%	1.05 (0.84-1.31)	.69
	77-111 repetitions	233	39%	1.00	
Sit-ups	19-61 repetitions	223	54%	1.40 (1.14-1.72)	<.01
	62-69 repetitions	218	43%	1.11 (0.89-1.39)	.36
	70-78 repetitions	227	40%	1.03 (0.82-1.30)	.78
	79-109 repetitions	224	38%	1.00	
2-mile Run (minutes and fraction of a minute)	11.12-13.52 minutes	233	34%	1.00	
	13.53-14.50 minutes	222	42%	1.23 (0.98-1.56)	.08
	14.51-15.50 minutes	204	44%	1.27 (1.00-1.61)	.05
	15.51-32.22 minutes	203	51%	1.49 (1.18-1.86)	<.01

ATAC indicates Advanced Tactical Athlete Conditioning program.
ECP indicates extreme conditioning program.

implementation. The increase in injury incidence was approximately the same for both groups. Overuse injuries also increased after the implementation of ATAC/ECPs, while traumatic injuries showed little change. It has been stated that overuse injuries typically occur at the beginning of new exercise programs and account for a majority of the injuries incurred.[23,24] Some of the common causes of overuse injuries include engaging in too much physical activity too soon, exercising too long, performing too much of one activity, and improper technique. Some studies have also found that the majority of injuries occurring in Army infantry Soldiers are attributed to physical fitness and sports activities.[6-10,25] However, the increase in overuse injuries was similar

Table 6. Unit PT and Personal Risk Factors for Injury Among Men Participating in ATAC/ECPs Using Multivariate Logistic Regression.

Variable	Subcategory of Variable	n	Odds Ratio (95% CI)	*P*
Body mass index (BMI)	<25	310	1.00	
	25-29.9	414	1.77 (1.29-2.44)	<.01
	30+	98	2.72 (1.67-4.43)	<.01
Tobacco	Nonsmoker	430	1.00	
	Smoker	392	1.80 (1.34-2.42)	<.01
Battalion	Infantry A	342	1.00	
	Infantry B	100	1.62 (1.01-2.61)	.05
	Cavalry	128	1.87 (1.20-2.92)	<.01
	Field artillery	139	1.36 (0.89-2.08)	.15
	Brigade support battalion	64	1.96 (1.09-3.54)	.03
	Brigade special troops battalion	49	1.20 (0.62-2.32)	.60
Times per week performing resistance training	No resistance training	80	1.00	
	<1 time per week	218	0.53 (0.31-0.92)	.03
	1-2 times per week	409	0.50 (0.29-0.84)	.01
	≥3 times per week	115	0.45 (0.24-0.85)	.01
Estimated miles per week of running	≤7 miles a week	401	1.00	
	7.01-9.00 miles a week	54	1.05 (0.57-1.94)	.87
	9.01-16 miles a week	290	1.00 (0.72-1.40)	.99
	>16 miles a week	77	2.24 (1.33-3.80)	<.01

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ECP indicates extreme conditioning program.

Variables entered into the model:

Age	How often do you participate in unit physical training?
BMI	Estimated total miles per week ran
Current smoking status	Agility Training
Battalion	Resistance Training

Table 7. Physical Fitness Test Risk Factors for Injury Among Men Participating in ATAC/ECPs Using Multivariate Cox Regression.

Variable	Level of Variable	n	Odds Ratio (95%CI)	*P*
Push-ups	20-56 repetitions	188	1.01 (0.62-1.63)	.97
	57-67 repetitions	207	1.11 (0.71-1.72)	.50
	68-76 repetitions	218	1.00 (0.66-1.50)	.99
	77-111 repetitions	222	1.00	
Sit-ups	19-61 repetitions	199	1.53 (0.94-2.50)	.09
	62-69 repetitions	205	1.03 (0.66-1.60)	.91
	70-78 repetitions	213	0.92 (0.60-1.39)	.68
	79-109 repetitions	218	1.00	
2-mile Run (minutes and fraction of a minute)	11.12-13.52 minutes	226	1.00	
	13.53-14.50 minutes	217	1.42 (0.95-2.12)	.09
	14.51-15.50 minutes	195	1.45 (0.95-220)	.08
	≥15.51 minutes	197	1.76 (1.13-2.74)	.01

Variables entered into the model: Age, battalion, push-ups, sit-ups, and 2-mile run.
Note: controlled for age and battalion.
ATAC indicates Advanced Tactical Athlete Conditioning program.
ECP indicates extreme conditioning program.

in both groups; therefore, no recommendations can be made for or against either program.

Unit PT Injury Risk Factors

For male Soldiers participating in ATAC/ECPs, those who ran greater distances, performed no resistance training, and served in either the Infantry B, Cavalry, or Brigade Support battalion were at a higher risk of injury. Male ATAC/ECPs participants who ran more miles per week during unit PT were at a higher risk of being injured than those who ran fewer miles per week. Other studies have also shown that risk of injury increases with miles run per week.[26-28] As mentioned earlier, analysis of APFT scores indicated those who ran greater distances per week (16 miles or more) had an average 2-mile run time of 14.6 minutes (±1.51 minutes), and those who ran fewer miles per week (less than 16 miles per week) had identical average 2-mile run times of 14.6 minutes (±1.61 minutes). Based on these data, running more than 16 miles per week for unit PT increases injury risk and provides no additional aerobic performance benefits.

Soldiers performing resistance training with their unit at least once per week were at a lower risk of injury than were Soldiers in units that did not perform resistance training. In a US Air Force study, Walker et al found that replacement of a majority of the traditional long-distance running with interval running, agility training, and functional strength training decreased the overall injury rates by 67%, and trainees scored higher on nearly all of the measured fitness parameters.[14] Adding resistance training to an aerobic training program can also be beneficial in the completion of job tasks or mission requirements. It has been shown that endurance training concurrent with resistance training improves load-bearing performance[29-32] and heavy lifting tasks,[32] and increases both short-term and long-term endurance capacity in sedentary and trained individuals.[33] In a meta-analysis, both strength training and concurrent training (combination of strength and endurance training) had larger effects on strength, 1.76 (95% CI, 1.34-2.18) and 1.44 (95% CI, 1.03-1.84) respectively, when compared to endurance training only (0.78, 95% CI, 0.36-1.19).[34] The evidence suggests that implementation of a combined resistance and endurance training program will enable Soldiers to complete specific mission tasks more effectively and with lower risk of injury than Soldiers who do not incorporate resistance training into their physical fitness programs.

Infantry A had the lowest injury incidence (38%) after the implementation of ATAC/ECPs. This battalion also had the youngest Soldiers, one of the lowest average BMIs, performed less running per week during unit PT, and performed the most sprint, resistance, and agility training per week in comparison to the other battalions. As previously mentioned, running more miles per week increases injury risk.[26-28] In addition, injury risk is higher for recruits with lower levels of lower-extremity muscle strength or who lack a consistent lower-extremity weight training program.[35,36] The Infantry A battalion's unit PT program involved less running and more cross-training activities, likely contributing to its lower injury rates.

Table 8. 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*
2-mile run (mean BMI)	1,091	28.2 BMI	26.1 BMI	25.2 BMI	24.6 BMI	<.01
Push-ups (mean BMI)	1,137	26.6 BMI	26.1 BMI	26.1 BMI	25.8 BMI	.03
Sit-ups (mean BMI)	1,134	27.0 BMI	26.1 BMI	25.7 BMI	25.5 BMI	<.01

BMI indicates body mass index.

Interviews of battalion commanders concerning their views regarding physical training and fitness offered additional insights into the difference in injury rates. For example, the Infantry A battalion commander spent the largest amount of money on fitness equipment for the unit and stated he considered mobility/agility to be the most important fitness ability. In comparison, other commanders (including the Infantry B commander) rated endurance as the most important fitness component. Upon examination of the 2 infantry groups (Infantry A and Infantry B), a difference in injury incidence of 15% was observed. Both commanders had also implemented an injury surveillance tracking system to collect injury metrics in their respective battalions. However, the Infantry A battalion reported its injury metrics every 3 weeks, whereas the Infantry B battalion collected them at the company level only and did not review or report them on a set schedule. Infantry A and Field Artillery, the 2 battalions with the lowest injury rates, ran the fewest miles per week for unit PT (10.1 miles and 9.2 miles, respectively), and both units tracked and reported their injury metrics at least once a month. Therefore, running fewer miles per week during unit PT and implementing an injury surveillance system[11] in which metrics are reported at least monthly may have a positive influence on lowering injury rates. In a consensus paper concerning military personnel involved with ECPs, Bergeron et al state that regular monitoring and accurate injury reporting may help reduce injury rates and optimize the physical fitness benefits of ECPs.[17]

Soldier Injury Risk Factors

In the current study, 62% of the men were considered either overweight or obese, which is similar to the US population, of which 64% of men aged 20 to 39 years are also considered either overweight or obese.[37] Injury risk for men was higher for those with a BMI classifying them as overweight or obese. Other investigations have found that Soldiers with a higher BMI are at a greater risk of being injured.[9,25,38] In a study involving infantry Soldiers, Reynolds et al found that Soldiers with a BMI of 25 or higher were at 2.2 times greater risk of being injured.[9] These findings are similar to the results found in this evaluation (1.8 and 2.7 times greater risk of injury for overweight or obese Soldiers, respectively).

According to the CDC, BMI is a fairly reliable indicator of body fatness for most people.[24] Therefore, Soldiers with higher BMIs will most likely have larger amounts of excess body fat. Investigations examining excessive body fat have shown that it adversely affects performance on military tasks that require both aerobic and strength components.[39-42] In a study investigating physical and physiological performance in Army Soldiers, Crawford et al found that Soldiers with 18% or less body fat performed significantly better on 7 of 10 fitness tests, compared to Soldiers with body fat greater than 18%. The authors suggested that Soldiers who have an excess amount of body fat may possess musculoskeletal and physiological fitness deficits, thereby decreasing military readiness and increasing risk for injury.[39] In an investigation of active duty Navy personnel, Bohnker et al examined mean BMI and overall physical readiness test scores (outstanding, excellent, good, satisfactory, and fail). As physical fitness test scores decreased, the mean BMI increased for both men and women.[42] This trend 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 as examined by quartile also had higher average BMIs.[43] Being overweight or obese may not only increase a Soldier's risk of incurring an injury, but may also have an adverse effect on aerobic and strength performance. The data is presented in Table 8.

Injury risk was higher in smokers than in nonsmokers. Previous studies have also demonstrated an increased general risk of injury in smokers compared to nonsmokers, and a definable increased risk of musculoskeletal

injury.[25,44-52] Also, among smokers themselves, the risk of injury has been shown to increase in direct relation to the number of cigarettes smoked per day.[25,44,47] 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.[53] In one investigation, researchers showed that tibial fracture healing to clinical union took 24% longer in smokers compared to nonsmokers,[54] while another study showed that smokers experienced impaired wound healing when compared to nonsmokers.[55] Therefore, harsh deployment environments and military occupational specialty requirements may result in weakened tissues from training and overuse, which may result in a greater susceptibility to injury among smokers who maintain high levels of physical fitness to meet demanding tasks.

Injury risk for Soldiers with the slowest 2-mile run times was higher when compared to those showing 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.[8,21,45,56,57] The Soldiers with the slowest 2-mile run times would have lower aerobic capacities than those with the fastest 2-mile run times.[58] 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 in comparison with Soldiers with greater fitness levels. Soldiers of lower fitness levels will not only be exercising at a higher percentage of their aerobic capacity to accomplish the same task as a more fit Soldier, but they will also perceive tasks as more difficult.[59] The greater physiological stress and/or fatigue experienced may lead to a higher risk of injury. Studies on fatigue have demonstrated decrements in proprioceptive ability,[60] a decrease in joint stability,[61] alterations in muscle activity,[60] changes in gait,[62-66] balance,[67,68] low-frequency fatigue,[69] neuromuscular function,[70] and ligament laxity.[71]

CONCLUSION

This project found similar increases in injury rates for units performing ATAC/ECPs and units not performing ATAC/ECPs. Therefore, no recommendations can be made for or against use of those programs. Risk factors associated with higher risk of injury following the start of a new exercise program included running longer distances during unit physical training, having a BMI of 25 or more, and smoking cigarettes. However, almost any level of resistance training appeared to produce a noticeable protective effect. A lower risk of injury was found for Soldiers who performed any resistance training compared to Soldiers who performed no resistance training.

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

RELEVANCE TO PERFORMANCE TRIAD

A key aspect of The Army Surgeon General's Performance Triad is the promotion of optimal physical activity among Army Soldiers, family members, retirees, and civilians. Optimal physical activity involves incorporating regular physical activity into daily routines while also minimizing injury risk. Prevention of injury during physical activity is crucial to preserving Soldier and unit readiness. The results of this analysis suggest that injuries can be minimized by limiting longer running distances and adding resistance training to unit physical training. The results also suggest that injury risks were lower for nonsmokers, Soldiers with higher aerobic endurance, and Soldiers maintaining a healthy body weight.

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