Warrior Model for Human Performance and Injury Prevention: Eagle Tactical Athlete Program (ETAP) Part II

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Abstract

Introduction: Physical training for United States military personnel requires a combination of injury prevention and performance optimization to counter unintentional musculoskeletal injuries and maximize warrior capabilities. Determining the most effective activities and tasks to meet these goals requires a systematic, research-based approach that is population specific based on the tasks and demands of the Warrior. **Objective**: The authors have modified the traditional approach to injury prevention to implement a comprehensive injury prevention and performance optimization research program with the 101st Airborne Division (Air Assault) at Fort Campbell, KY. This is second of two companion papers and presents the last three steps of the research model and includes *Design and Validation of the Interventions, Program Integration and Implementation, and Monitor and Determine the Effectiveness of the Program*. **Methods**: An 8-week trial was performed to validate the Eagle Tactical Athlete Program (ETAP) to improve modifiable suboptimal characteristics identified in Part I. The experimental group participated in ETAP under the direction of a ETAP Strength and Conditioning Specialist while the control group performed the current physical training at Fort Campbell under the direction of a Physical Training Leader and as governed by FM 21-20 for the 8-week study period. **Results**: Soldiers performing ETAP demonstrated improvements in several tests for strength, flexibility, performance, physiology, and the APFT compared to current physical training performed at Fort Campbell. **Conclusions**: ETAP was proven valid to improve certain suboptimal characteristics within the 8-week trial as compared to the current training performed at Fort Campbell. ETAP has long-term implications and with expected greater improvements when implemented into a Division pre-deployment cycle of 10-12 months which will result in further systemic adaptations for each variable.

Introduction

This paper is the second of two companion papers detailing the systematic and data driven injury prevention and performance optimization training program (Eagle Tactical Athlete Program- ETAP) to reduce the risk of unintentional musculoskeletal injuries and improve physical readiness in Soldiers of the 101st Airborne Division (Air Assault). This six step injury prevention and performance model was developed based on the conventional public health approach to injury prevention and control[1-3] and was modified to include *Task and Demand Analysis*. The first three steps of the model were detailed in Warrior Model for Injury Prevention and Human Performance: Eagle Tactical Athlete Program (ETAP) – Part I and included *Injury Surveillance*, *Task and Demand Analysis*, and *Predictors of Injury and Optimal Performance*. The current paper describes the last three steps of the model and includes *Design and Validation of the Interventions, Program Integration and Implementation, and Monitor and Determine the Effectiveness of the Program*.

At the initiation of this research with 101st Airborne Division (Air Assault), the standard physical training guideline used at Fort Campbell was Field Manual (FM) 21-20, published by the Department of the Army.[4] Although this manual covers the fundamental principles of cardiovascular fitness, body composition, muscular endurance, strength, and flexibility, anecdotal reports suggest daily physical training still emphasizes training for performance on the Army Physical Fitness Test (APFT): push-ups, sit-ups, and two-mile run. This assessment encompasses few of the characteristics critical to achieve optimal physical readiness and performance, or reduce injury risk.[5] Unfortunate consequences of such isolated training increase the risk of certain musculoskeletal injuries.[6]

Several military and civilian based training programs have been developed and/or marketed as training programs specific to U.S. Army Soldiers.[7-9] Common to these programs is the concept of treating the Soldier as a "tactical athlete." Consequently, these physical training programs are similar to strength and conditioning programs developed for athletes at the university and/or professional level, incorporating aerobic and anaerobic components as well as muscular strength, endurance, and agility. While a few programs have been based on predictors of injury and optimal performance,[10] none of the programs were developed based on injury surveillance of military populations in which the program was implemented or the physiologic, musculoskeletal, and biomechanical demands associated with military-specific training and tactical operations. Many of the programs target individual Soldiers rather than units, potentially making it difficult to implement the program on a larger scale.[7-9] Additionally, few studies have designed and validated an intervention program using Soldiers in regular Army combat units, whose training schedule is largely influenced by deployment cycles and their associated preparatory activities. Only a few of these training programs have been evaluated to determine if the risk of injury is reduced while maintaining or improving physical performance, including the APFT.[11] Consistent with the public health approach to injury prevention and control,[1-3] it is imperative to monitor and determine the effectiveness of these training interventions to reduce injury and optimize performance.

The purpose of this paper is to describe the last three steps of the research model- *Design and Validation of the Interventions, Program Integration and Implementation, and Monitor and Determine the Effectiveness of the Program*,. It was hypothesized that performance of ETAP would result in favorable adaptations to laboratory, field, and APFT performance compared to the current training performed at Fort Campbell as governed by FM 21-20.

Design and Validation of Interventions

<u>Methods</u>

Subjects

A sample of 60 male and female Soldiers from the 101st Airborne Division (Air Assault) were recruited from a single Brigade through posted advertisements and information sessions arranged by the investigators. All subjects were cleared for active duty without any injury profile prescribed throughout the study period or within the three months prior to enrollment. Subjects were matched on age, gender, and two-mile run time from their last APFT and then one member of each pair was randomly assigned to either an experimental group- ETAP (N: 30, Age: 24.6 ± 5.2 years, Height: 168.5 ± 24.5cm, Mass: 68.3 ± 3.3kg) or control group- current PT (N: 30, Age: 25.1 ± 5.8 years, Height: 168.5 ± 25.5cm, Mass: 69.1 ± 3.3kg). Human subject protection for the current study was approved by the University of Pittsburgh, Dwight D. Eisenhower Army Medical Center, Army Clinical Investigation Regulatory Office, and Army Human Research Protection Office. All tests were conducted at the Human Performance Research Center, Fort Campbell, KY, a remote research facility operated by the Neuromuscular Research Laboratory, University of Pittsburgh.

ETAP Overview

ETAP is a cyclic program which allows for modifications to the individual training cycles according to unit schedules and missions. When implemented, each cycle is separated by one to two weeks of tapered activity to ensure proper recovery and to reduce the risk of overtraining. Each cycle is designed to build upon the previous cycle and varies in intensity and duration. ETAP is designed for implementation with little to no equipment and can be easily executed in garrison or while deployed. Overall volume, intensity, rest, and distance varies across the phases: phase I focuses on general adaptation and introduction to the exercises; phase II focuses on gradual increase in volume; phase III focuses on gradual increase in intensity with less volume, and phase IV focuses on taper prior to the post-test, deployment, or cycle reset. The program consisted of five main workout sessions per week over eight weeks, each with a specific fitness component focus (Table 1). Each workout session began with a dynamic warm-up and finished with a cool-down and static stretching. Each session was dedicated to one of the following training objectives: Day-1) speed, agility, and balance; Day-2) muscular strength; Day-3) interval training; Day-4) power development; and Day-5) endurance training. The total workout duration for each daily physical training session was consistent with the guidelines published in FM 21-20 and as instructed at Fort Campbell.

The Day-1 workout session was designed to improve anaerobic power and capacity (which were identified as suboptimal during *Predictors of Injury and Optimal Performance*) and incorporated speed and agility exercises. Interval training with approximately a 1:3 or 1:2 work to rest ratio was incorporated for anaerobic system enhancement. Activities included shuttle runs, sprints, lateral movement drills, and agility drills. Shuttle runs and sprints used a funnel design, with the volume (total distance) progressing from high (274 meters (m)) to low (27 m) which dictated that the intensity progresses from low to high. Sprint training has been reported to induce neural adaptations, specifically increased nerve conduction velocity and motor-neuron excitability.[12] Agility and lateral movement (line, cone, and ladder) drills progressed from simple patterns with shorter duration, distance, or volume to more complex patterns with longer duration, distance, or volume. Agility drills included line, cone, ladder drills, and advance shuttle and combined skills activities.

The Day-2 workout session was designed to improve muscular strength and muscular endurance, with the focus of increasing total body muscular strength. Strength training consisted primarily of resistance exercises that required no to a minimal amount of equipment and therefore

TABLE 1 **ETAP Design/Overview**

DAY 1: Anaerobic Conditioning Shuttle runs, sprints, lateral movement, and agility Shuttle runs and sprints use a funnel design through an eight week cycle. The longest distance (274 m) will be performed early progressing to the shortest (27 m) distance. The volume (total distance) progresses from high to low which dictates that the intensity must progress accordingly, from relatively low to high. Agility and lateral movement drills will progress from simple patterns and shorter duration or distance to more complex patterns and longer duration or distance.	DAY 2: Resistance I Strength training consist of performing exercises using no equipment to a minimal amount of equipment, that can be executed anywhere. The goal is to increase total body muscular strength. The workouts are balanced for total body development; front/back, left/right, and top/bottom.
DAY3: Aerobic Intervals/Balance drills Aerobic intervals include running distances ranging from 800 – 1200 meters, individual dependent, for time followed by active or passive recovery. Interval run time goals is from 3:30 – 5:00 minutes. The number of aerobic intervals progresses from 3 – 5 depending on group and program length. Interval running recovery duration will progress from a longer to shorter time period, initially a 1:1 work to rest ratio. Static and dynamic balance drills are performed with eyes open and eyes closed. Progression is dependent on group ability.	DAY 4: Resistance II Builds on Day 2, Resistance I workout. Strength training consist of performing exercises using no equipment to a minimal amount of equipment, that can be executed anywhere. Includes basic resistance training exercises along with upper and lower body plyometric exercises. The goal is to improve muscular strength and power.
DAY 5: Aerobic Conditioning Distance runs and foot marches are performed. Runs and foot marches can be executed in formation or in ability groups. The goal is to increase VO_{2max} and foot march efficiency and progresses from shorter to longer distances.	

could be executed anywhere. Equipment employed included the following: Interceptor Body Armor (IBA), body weight, sandbags, partner resistance, resistance tubing, and dumbbells. Exercise intensity, volume and rest were prescribed according to a recommendation by the American College of Sports Medicine[13] and the volume was manipulated throughout the cycle by altering the duration the exercises were performed. The workout session incorporated full body strength training to ensure a well balanced program and exercises were selected specifically to address muscle weaknesses and/or imbalances as identified during *Predictors of Injury and Optimal Performance*. Targeted muscles included hip adductor/abductor, hamstrings, the rotator cuff and trunk rotators.

The Day-3 workout session was designed to improve aerobic capacity through interval runs.[14, 15] The distance for the interval run ranged from 800-1200m, with the interval run lasting between four to five minutes and performed at or near VO_{2max}. Running faster than VO_{2max} pace does not necessarily produce a greater aerobic benefit; therefore, the interval distance was carefully monitored and adjusted individually.[16] Initially subjects were assigned to one of three interval distances based on APFT two-mile run times (≤ 15:00, 1200m; 15:01 - 17:59, 1000 m; ≥ 18:00, 800m). When a subject consistently finished the interval run in less than four minutes or greater than five minutes, then he/she was moved into a longer or shorter distance group, respectively. Prior to the workout, each Soldier was given an individualized goal time to complete the interval runs, based on the average time for his/her interval runs from the previous week. The work to rest ratio was designed to be close to 1:1, but varied by individual due to group size and individual finishing times. Early in the eight-week cycle, the rest time was slightly higher than the work time. As the cycle progressed, the rest time decreased slightly (with a minimum of 4:30 minutes). Also, the cycle began with two to three intervals with five minutes of rest/recovery and gradually progressed to four to five intervals with 4.5 minutes of rest/recovery. Static and dynamic balance drills also were performed at the completion of this workout. Several variation of one leg balance drills with eyes open and eyes closed were also performed.

The Day-4 workout session was designed to improve muscular strength and explosive power. This session built on the main workout session from Day-2. As with Day-2, the volume was manipulated throughout the cycle by altering the time that the exercises were performed. During the first four weeks of the cycle, circuit training which incorporated full body exercises along with upper and lower body plyometric exercises was performed. During weeks five and seven, the IBA was worn during the circuit, with no IBA during weeks six and eight to allow for rest/recovery. Proper landing technique was taught and landing drills executed to decrease ground reaction forces, which were identified in the companion paper as suboptimal. Intensity and volume of plyometric exercises were carefully monitored and introduced according to safety recommendations.[17, 18] Lower body plyometric exercises have been shown to reduce GRF due to a strength increase in the hamstring muscles accompanied by an improvement in the flexion/extension ratio.[19-22] Teaching and utilizing proper landing techniques also reduces the impact forces, therefore decreasing the risk of injury.[23] Training volume for lower body plyometric exercise was limited to 40-60 landings (4-6 exercises) per session and the jump intensity was limited to vertical jumps, tuck jumps, lateral and front-to-back line and cone hops/jumps, jumping rope, five dot drill and small box drills and landings. Upper body plyometric activities included APFT speed pushups, clapping pushups, and a variety of medicine ball exercises.

The Day-5 workout session was designed to improve aerobic endurance. Distance runs and foot marches were performed on alternate weeks. The goal was to increase aerobic capacity (VO_{2max}) and foot march efficiency and therefore progressed from shorter to longer distances. For the foot march, the minimum pace was set at three miles per hour (20 min/mile) as per Fort Campbell standards. The initial distance was three miles and was increased by a half mile each march. Additionally, the load carried was gradually increased as follows: no load, IBA/Advance Combat Helmet (ACH), IBA/ACH with a 6.8 kg rucksack, and IBA/ACH with a 11.4 kg rucksack. Distance runs began with two to three miles at a steady pace and gradually progressed up to six miles.

Experimental Design

A pretest/post test randomized controlled design was used for this study. All subjects reported to the Human Performance Research Center for pre- and post-intervention testing. The experimental group participated in ETAP under the direction of an ETAP Strength and Conditioning Specialist while the control group performed current physical training at Fort Campbell as governed by FM 21-20 for the eight-week study period under the direction of the groups Physical Training Leader. Subjects reported each morning, Monday through Friday, at the regularly scheduled physical training time, for eight weeks. The ETAP Strength and Conditioning Specialist and Physical Training Leader were solely responsible for instructing physical training and were not involved with the data collection procedures.

Laboratory Testing

The laboratory testing procedures used to evaluate the effectiveness of ETAP to modify biomechanical, musculoskeletal, and physiological characteristics were identical to those described in *Predictors of Injury and Optimal Performance* of Warrior Model for Injury Prevention and Human Performance: Eagle Tactical Athlete Program (ETAP) – Part I. For the sake of brevity and repetitiveness any protocol deviations from the companion paper and related variables are described below.

A low back and hamstring flexibility protocol was assessed with the Novel Products Acuflex® I Sit and Reach Box (Rockton, IL). With shoes removed, the subject sat on the floor with the knees straight and feet flat against the box. The subject placed one hand on top of the other with the fingers aligned and then reached out as far as possible without jerking or bouncing while ensuring the hands stayed in proper position and paused momentarily for measurement. The average of three trials was recorded.

Field Testing

Maximum vertical jump height was determined using the Vertec (Questtek Corp, Northridge, CA). Standing reach was obtained and recorded by having the subject stand directly under the Vertec and extend the dominant arm and hand to gently touch the highest vane possible. Each subject performed a standing countermovement jump for maximum height, reaching the highest vane on the Vertec. Vertical jump was obtained by determining the difference of the maximum jump height and standing reach. A 30-60 second (s) rest was provided between trials. The average of three trials was recorded.

The standing broad jump was measured as the subject performed a countermovement and a two legged forward jump for maximal distance (standing broad jump). Subject's arms were free to move throughout performance of the standing broad jump. Subjects were allotted approximately 30-60 s rest between trials. Distance was measured between the starting position and the most posterior heel-ground contact without the subject falling. The average of three trials was recorded.

The agility task was performed as the subject started in a two point stance straddling the middle cone of three cones, each separated by 4.6m. The subject sprinted (either direction) to the adjacent cone, touched the line with the outside hand and changed direction (ensuring not to pivot all the way around), sprinting past the middle cone to the far cone. The subject touched the line with the outside hand, changed direction, and sprinted past the middle cone, which was the finish line. The time to complete the drill was averaged across three trials. Subjects were allotted approximately 30-60 s rest between trials.

The shuttle run was performed in a straight line between two

Table 2
Pre- and Post-Static/Dynamic Balance (Mean ± SD)
101st Airborne Division (Air Assault)

	Exp - Pre	Exp - Post	Control - Pre	Control - Post
A/P EO (NM)	2.5 ± 0.6	2.3 ± 0.5	2.5 ± 0.6	2.5 ± 0.8
M/L EO (NM)	3.0 ± 1.0	2.9 ± 0.8	3.2 ± 0.8	3.4 ± 1.1
V EO (NM)†	4.3 ± 1.7	4.1 ± 1.6	4.5 ± 1.7	4.6 ± 2.2
A/P EC (NM)†	6.7 ± 3.5	5.1 ± 1.5	7.0 ± 3.6	6.2 ± 2.1
M/L EC (NM)†	9.5 ± 3.8	7.8 ± 2.1	10.1 ± 3.7	9.5 ± 3.1
VEC (NM)	14.2 ± 10.1	10.3 ± 4.0	15.2 ± 11.2	12.7 ± 5.6
MLSI (NM)	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
APSI (NM)	0.15 ± 0.01	0.15 ± 0.01	0.15 ± 0.01	0.15 ± 0.01
VSI (NM)†	0.38 ± 0.04	0.36 ± 0.04	0.38 ± 0.05	0.37 ± 0.05
DPSI (NM)†	0.41 ± 0.04	0.39 ± 0.04	0.41 ± 0.04	0.40 ± 0.05

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 3
Pre- and Post-Flexibility (Mean ± SD)

	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
Active Knee Extension (deg)*#	21.6 ± 8.1	20.7 ± 8.8	24.4 ± 8.6	28.5 ± 9.2
Ankle Plantarflexion (deg)	54.4 ± 7.5	51.5 ± 8.3	55.6 ± 5.7	52.5 ± 5.5
Ankle Dorsiflexion (deg)*†	9.2 ± 6.0	10.7 ± 4.7	10.6 ± 5.0	9.5 ± 4.7
Low Back/Hamstring (cm)*†	17.2 ± 2.7	18.6 ± 2.4	15.6 ± 4.1	15.6 ± 4.0
Torso Rotation (deg)*†#	68.7 ± 11.7	77.6 ± 12.4	72.3 ± 7.7	68.2 ± 7.9

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 4
Pre- and Post-Strength (Mean ± SD)

	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
Knee Flex (%BW)†	119.1 ± 29.3	128.0 ± 29.5	118.1 ± 25.4	122.6 ± 19.5
Knee Ext (%BW)*†#	236.0 ± 48.9	244.1 ± 42.3	243.3 ± 50.6	223.4 ± 31.8
Knee Flex/Ext Ratio	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.6 ± 0.1
Shoulder Int Rot (%BW)	54.0 ± 15.1	53.0 ± 16.0	53.4 ± 12.7	52.8 ± 9.9
Shoulder Ext Rot (%BW)	42.4 ± 9.1	38.1 ± 7.3	42.3 ± 7.7	39.8 ± 6.1
Shoulder ER/IR Rot Ratio	1.3 ± 0.3	1.4 ± 0.4	1.3 ± 0.2	1.3 ± 0.2
Torso Rotation (%BW)*†	128.5 ± 33.5	137.6 ± 27.4	137.7 ± 26.8	136.9 ± 30.5

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 5
Pre- and Post-Physiology (Mean ± SD)

	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
Body Fat (%BF)	19.0 ± 7.5	18.9 ± 7.9	18.7 ± 7.3	19.3 ± 7.1
Anaerobic Power (W/kg)*†#	11.9 ± 2.3	14.0 ± 2.4	11.7 ± 2.2	12.7 ± 2.2
Anaerobic Capacity (W/kg)†#	7.5 ± 1.2	8.1 ± 1.0	7.2 ± 1.3	7.6 ± 1.0

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 6 Pre- and Post-Field Tests (Mean ± SD)				
	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
Vertical Jump (cm)*†#	54.4 ± 11.9	56.6 ± 11.7	55.6 ± 10.2	56.6 ± 10.4
Horizontal Jump (cm)†#	194.1 ± 33.3	201.9 ± 32.8	192.0 ± 27.4	197.1 ± 29.7
Pro Agility (s)*†	5.4 ± 0.5	5.3 ± 0.4	5.4 ± 0.5	5.4 ± 0.4
Shuttle Run (s)*†	69.2 ± 6.2	66.8 ± 6.3	71.0 ± 8.0	71.3 ± 8.5

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 7 Pre- and Post-APFT (Mean ± SD)				
	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
Pushup (reps)	51.7 ± 13.0	53.3 ± 9.0	53.6 ± 13.9	54.4 ± 12.3
Situp (reps)*†#	58.9 ± 13.3	68.0 ± 10.0	58.6 ± 8.6	62.5 ± 9.8
2 Mile (min)*†#	16.6 ± 2.4	15.4 ± 2.0	16.6 ± 2.6	16.0 ± 2.0

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

Table 8 Pre- and Post-Biomechanics (Mean ± SD)				
	101st Airborne Division (Air Assault)			
	Exp - Pre	Exp - Post	Control - Pre	Control - Post
HipFlexIC (°)	39.7 ± 11.5	41.6 ± 11.7	40.3 ± 10.0	42.2 ± 9.9
HipAbdIC (°)	-5.1 ± 3.5	-4.3 ± 3.8	-4.4 ± 3.8	-4.6 ± 3.4
KneeFlexIC (°)	24.3 ± 8.2	25.1 ± 7.5	23.4 ± 8.3	24.7 ± 7.7
KneeVVIC (°)	3.2 ± 5.0	2.9 ± 4.8	4.1 ± 6.6	1.5 ± 5.7
KneeFlexMax (°)	89.0 ± 12.0	87.9 ± 10.5	85.4 ± 14.3	86.4 ± 9.7
PeakvGRF (%BW)	209.9 ± 49.0	197.0 ± 48.1	254.7 ± 71.2	232.3 ± 60.6
AnkleFlexIC (°)	-7.1 ± 14.2	-5.4 ± 14.9	-5.9 ± 16.1	-7.2 ± 15.6
AnkleFlexMax (°)	26.2 ± 5.7	25.3 ± 5.0	25.9 ± 5.1	25.2 ± 4.1

*Significant pre/post intervention between group differences ($p < 0.05$)
†Significant pre/post intervention experimental group differences ($p < 0.05$)
#Significant pre/post intervention control group differences ($p < 0.05$)

FIGURE 1

ETAP ICS CURRICULUM

Day 1

0930 - 0945	Introduction to ETAP ICS
0945 - 1000	Paperwork: Informed Consent
1000 - 1130	ETAP Day 1 Workout · Anaerobic intervals · Energy pathways · Cone drills
1130 - 1300	Lunch break
1300 - 1330	Introduction to ETAP Basic exercise physiology presentation
1330 - 1345	Dynamic warm up: Classroom presentation
1355 - 1405	Static stretching: Classroom presentation
1405 - 1415	Break
1415 - 1425	Dynamic warm up: Practice and corrections in gym
1425 - 1450	Anaerobic conditioning: Classroom presentation
1450 - 1515	Agility, balance, & coordination: Walkthrough/Interactive presenation in gym
1515 - 1530	Agility ladder drills: Practice and setup

Day 2

0930 - 0945	Performance testing information: Classroom brief
0945 - 0950	Transition to gym for Day 2 workout
0950 - 1120	ETAP Day 2 Workout · Full body resistance training day
1120 - 1130	Question and Answer period
1130 - 1300	Lunch break
1330 - 1430	Nutrition for athletes: Classroom presentation · Basic nutrition concepts · Sports nutrition concepts · Weight control information · Supplements: Use of and cautions
1430 - 1440	Break
1440 - 1520	Resistance I/Strength Training: Classroom presentation · Principles/guidelines and proper techniques · Muscle contraction · Partner resisted exercise · Alternative forms of resistance · Alternative forms of workouts · Workout considerations
1520 - 1525	Aerobics intervals (Day 3 Preview): Classroom
1525 - 1530	Question and Answer period

Day 3

0930 - 1100	ETAP Day 3 Workout · Aerobic intervals · Static balance drills
1100 - 1120	Balance drills discussion: Static and dynamic
1120 - 1130	Question and Answer period
1130 - 1300	Lunch break
1300 - 1400	Aerobic intervals/interval running: Classroom presentation · Interval running concepts · Energy pathways · VO2max and LT concepts/theories · LT improvement concepts · Measuring intensity: RPE & heartrate · Using heartrate monitors and software · Field measures of aerobic
1400 - 1410	Discussin & interpreting heartrate graphs
1410 - 1420	Break
1420 - 1510	Partner resisted exercise: Practice in gym
1510 - 1520	Proper squat technique: Discussion and practice
1520 - 1530	Question and Answer period

Day 4

0930 - 1110	ETAP Day 4 Workout · IBA Workout · Medicine ball exercises
1110 - 1120	Alternative forms of resistance: Show and tell
1120 - 1130	Question and Answer period
1130 - 1300	Lunch break
1300 - 1320	Landing and IBA Workout: Classroom presentation
1320 - 1325	Discussing & interpreting heartrate graphs
1325 - 1400	Resistance II: Classroom Presentation
1400 - 1410	Break
1410 - 1420	Exercise demonstrations and suggestions from Physical Training observations: in gym
1420 - 1430	Push press: Discussion and demonstration Medicine ball and push press: Practice in gym
1430 - 1500	Functional and agility training: Discussion, demonstration, and practice various forms of: · Hops: line and cone · Vertical jumps · Jump rope intensities · Unstable surface training
1500 - 1515	Putting it all together: Classroom presentation
1515 - 1525	Workout cards and DVD: Explanation
1525 - 1530	Course evaluation and distribution of Certificates of Completion

cones, separated by 22.9m and timed for a total completion of 274.3m (six laps). Subjects were instructed to touch the end lines with their hands prior to change in direction. One trial was completed and recorded.

The APFT was conducted by a non-commissioned officer in charge responsible for administering and scoring the individual components of the APFT. Subjects were allotted two minutes to perform maximum repetitions of sit-ups, two minutes to perform maximum repetitions of push-ups, and timed two mile run according to APFT standards as outlined in FM 21-20. A 10-minute rest period was allowed between each testing component.

Statistical Analysis

Data were examined to assess the assumptions of normality and of equality of variance. These assumptions were not met in the case of some variables. Descriptive statistics (measures of central tendency and measures of dispersion) were estimated for all variables. The absolute differences from pre- and post-testing for the experimental and control group were calculated for all variables. Both parametric tests for normally distributed data and non-parametric tests were used to compare absolute differences from baseline between the experimental and the control group. The results of the non-parametric test (Wilcoxon rank-sum test) agreed with the results of the corresponding parametric test (independent samples t-test) with respect to direction of change and significance of the results in the majority of the variables and reported as parametric analysis. Statistical significance was set at $p < 0.05$ for all variables.

Results

The 8-week trial was comprised of 35 training sessions and accounted for five days of no scheduled activities according to the Fort Campbell operating schedule. The average attendance for the experimental group was 89% (31 sessions) with a range of 54-100%. A minimum attendance of 80% of the training sessions was achieved by 80% of the subjects in the experimental group. The average attendance for the control group was 94% (33 sessions) with a range of 71-100%. A minimum attendance of 80% of the training session was achieved by 96% of the subjects in the control group.

Flexibility/range of motion, strength, and balance data are presented in Tables 2- 4. Compared to the control group, the experimental group demonstrated improved active knee extension ($p < 0.001$), ankle dorsiflexion ($p = 0.018$), lumbar/hamstring flexibility ($p < 0.001$), and torso rotation flexibility ($p < 0.001$). No significant group differences were demonstrated in ankle plantar flexion ($p > 0.05$). Compared to the control group, the experimental group demonstrated significant improvements in knee extension strength ($p < 0.001$) and torso rotation strength ($p = 0.036$). No significant group differences were demonstrated in knee flexion or shoulder strength ($p > 0.05$). No significant group differences were demonstrated in eyes open or eyes closed balance ($p > 0.05$).

Physiological, field assessment, and APFT data are presented in Tables 5- 7. No significant group differences were demonstrated for percent body fat ($p > 0.05$). Compared to the control group, the experimental group demonstrated significant improvements in anaerobic power ($p = 0.019$). Compared to the control group, the experimental group demonstrated significant improvements in the sit-up ($p = 0.022$) and two mile timed run ($p = 0.039$) portions of the APFT, vertical jump ($p = 0.042$), agility ($p = 0.019$), and 300 yard shuttle run ($p = 0.005$).

Biomechanical data are presented in Table 8. No significant differences were demonstrated for the biomechanical variables ($p > 0.05$).

Discussion

The purpose of this paper was to detail the last three steps of the injury prevention and performance optimization model: *Design and Validation of the Interventions, Program Integration and Implementation, and Monitor and Determine the Effectiveness of the Program*. The Eagle Tactical Athlete Program (ETAP) is a comprehensive physical training program for performance optimization and injury mitigation and was based on the tasks and demands of the 101st Airborne Division (Air Assault) Soldiers. It was demonstrated to induce favorable adaptations to a significant number of modifiable characteristics following eight weeks of training as indicated by improvements in strength, flexibility, balance, power, field tests, and APFT. Although several variables did not demonstrate improvements, the authors acknowledge limited exposure with an 8-week program may have contributed to such results. The program duration will be accounted for when periodized to meet the pre-deployment training cycle of 10-12 months. The effectiveness of ETAP to reduce the risk of unintentional musculoskeletal injuries and optimize physical readiness and performance in Soldiers of the 101st Airborne will be assessed over the next year.

Flexibility/range of motion of the hamstring, calf, and torso improved in the experimental group relative to the control group. The results indicate that dynamic stretching with warm-up and static stretching with cool-down as incorporated with ETAP are effective ways to improve flexibility compared to static stretching with warm-up typically seen in the traditional PT. Improvements in flexibility and range of motion may be important in decreasing the risk of musculoskeletal injuries. Hartig and Henderson[24] reported that hamstring flexibility improved in military infantry basic trainees who participated in a stretching intervention and that these trainees also sustained significantly fewer lower extremity overuse than the controls during a 13-week infantry basic training course. It has also been reported that individuals with less hamstring flexibility, measured using a variety of techniques, are significantly more likely to develop hamstring and quadriceps muscle injuries, low back pain, and patellar tendinitis.[25-27] Decreased flexibility of the gastroc-soleus complex (either alone or in conjunction with other variables) has also been identified in increasing the risk of patellofemoral pain syndrome, achilles tendinitis, ankle sprains, and medial tibial stress syndrome.[28-31]

Knee extension, knee flexion, and torso rotation strength improved in the experimental group relative to the control group. Lower levels of strength may be associated with an increased risk of injury or may be a residual effect from a previous injury. In a prospective study of Australian footballers, Orchard et al. reported that hamstring injury was significantly associated with hamstring weakness as measured by peak torque at 60°/sec.[32] Decreased hamstring strength has also been identified in female athletes who subsequently sustained an injury to the anterior cruciate ligament as compared to male matched controls.[33] Individuals with a history of low back pain demonstrate significantly lower trunk strength than controls.[34] As a general guideline for resistance training, the intensity of 70-80% of one repetition maximum for eight to twelve repetitions and three sets for two to three times a week is recommended for novice athletes.[35] The volume and intensity utilized in ETAP were similar to these recommendations. No significant improvements were seen in shoulder strength, which may be the result of an increased focus of lower body strength and endurance.

Single-leg balance with eyes closed was improved in the experimental group; however, no significant differences with eyes open or group differences were demonstrated. Several studies analyzed biomechanical and neuromuscular characteristics after neuromuscular training (typically a combination of plyometric, resistance, balance, perturbation, and agility training) and reported increases in balance performance.[21, 36, 37] Myer et al.,[21] included several dynamic balance exercises on an unstable disc three times a week for seven weeks. The current study incorporated balance exercises once per week and the balance exercises were performed on a stable surface, which was sufficient to improve single-leg balance with the eyes closed. It is possible the lack of significant group differences in the current study may be multifactorial such that both the low frequency and intensity/difficulty of balance exercises were not sufficient to induce large enough changes. In addition, balance, particularly with the eyes open, may be positively impacted by other training modalities (e.g., squats, lunges, ruck marches on an uneven surface) to which both groups may have been exposed.

Neither group demonstrated a significant change in body weight nor percent body fat. Although exercise training increases energy expenditure which may contribute to a negative energy balance and thus body weight loss, numerous studies have found that exercise alone results in little if any weight loss[38-40] This is explained in part by the fact that moderate exercise does not create a large enough energy gap to promote body weight loss.[38] ETAP training was intended to induce adaptations to promote aerobic fitness, anaerobic power and capacity, muscular strength, flexibility, and balance, not necessarily to promote body weight loss. Also, none of the Soldiers in the current study received any instructions on modifying their diets. There is little evidence to suggest exercise alone will provide the amount of weight loss similar to that generally achieved by diet restriction.[38, 39] Research has shown that higher levels of exercise and or the addition of energy restriction may be necessary to promote significant body weight and fat loss[39, 41-43]

Relative to the control group, the experimental group demonstrated significant improvements in anaerobic power. During the Wingate test, higher anaerobic power is a function of pedaling speed and torque. It is possible that this improvement in anaerobic power resulted from training effects induced by the sprinting and agility exercises along with resistance exercises performed during ETAP. The experimental group also demonstrated a significant improvement in anaerobic capacity. These improvements may be the result of interval training and the varied intensity of exercise that was provided during ETAP. Significant improvements in agility and the shuttle run were seen in the experimental group as compared to the control group. These adaptations may be the result of the targeted training provided by ETAP. Many athletic movements and tactical maneuvers rely on anaerobic capacity, power, and a combination of agility-type activities.

In terms of the APFT, the cardinal assessment of fitness in the U.S. Army, the experimental group demonstrated significant improvements in the sit-ups and two mile run relative to the control group. The key finding is that ETAP was able to improve two mile run performance without the high running mileage typical seen with Army PT. The results of the current study, when combined with previous epidemiological studies, indicate that it may be possible to reduce the incidence of injury during military training by reducing running mileage without compromising fitness as assessed by the APFT.[44-46]

No significant improvements in any of the biomechanical characteristics were seen in either group. Previous research that investigated the effect of plyometric programs coupled with resistance programs on lower extremity kinematics has produced conflicting results.[21, 43, 48] Myer et al.,[21] reported an increase in hip abduction angle and no changes in knee valgus/varus angle after seven weeks of a plyometric training program and a balance training program. Lephart et al.,[47] reported an increase in knee flexion and hip flexion following an eight-week program that incorporated resistance, balance, and plyometric training. However, no changes in knee valgus/varus and hip abduction angle were observed. Similarly, Chappell et al.,[48] reported an increase in knee flexion angle and no changes in knee valgus/varus and hip abduction angle after six weeks of neuromuscular training. The validation trial of ETAP was based on an 8-week trial and may not have been a sufficient duration to induce biomechanical adaptations during landing activities as ETAP was designed to improve multiple areas throughout the 8-week trial with the understanding of eventual expansion to a pre-deployment cycle.

There are several limitations to the current study. Although the U.S. Army provides field manuals to guide physical training, physical training is administered at the discretion of the unit leader and can vary extensively within a Division. It was requested of the Physical Training Leader that he instruct physical training for the control group as he would if not participating in the trial. Within the Division this could suggest an overlap in training or similar training being performed relative to the experimental group. In addition, many military personnel train on an individual basis to supplement unit PT but were instructed to restrict outside exercise/training beyond morning physical training while enrolled in the 8-week trial. This was not monitored in the current study, however if performed, this training may have enhanced the results of the control group to improve certain characteristics. Soldiers performing ETAP demonstrated significant improvements in several variables that are vital to optimizing physical readiness and performance and potentially reducing the risk of unintentional musculoskeletal injuries. Implementation of ETAP into the Division should have long-term implications to improve physical readiness of the Soldier when periodized across a 10-12 month pre-deployment cycle when sufficient exposure and duration is achieved for all components of physical training to allow for complete adaptation of the suboptimal characteristics.

The Department of the Army has recognized the need for updated physical training guidelines to better address more aspects of physical fitness in order to improve performance and physical readiness while reducing the risk of injury. The Army replaced FM 21-20, which was the guideline that governed physical training being performed at Fort Campbell at the time of this study, with TC 3-22.20, *Army Physical Readiness Training*.[10] Epidemiological studies have demonstrated the effectiveness of PRT to reduce injuries while maintaining or improving APFT during Basic Combat Training (BCT) and Advanced Individual Training (AIT).[44-46]

Future studies and programs should incorporate more upper body training. No changes in upper body strength were demonstrated in either group. However, previous studies have reported a high incidence of shoulder instability, dislocation, and rotator cuff tears in the military population[49-51] and that reduced shoulder internal and external rotation peak torque is typically seen with shoulder impingement syndrome and instability.[52-54] Future studies should also monitor and attempt to further control for physical training performed outside of daily Army PT. Finally, it is important to incorporate meal planning and nutritional educational sessions in any injury prevention and performance optimization program if body composition changes are desired.

The final two steps of the public health approach to injury prevention and control: *Program Integration and Implementation* and *Monitor and Determine the Effectiveness of the Program* are currently ongoing and will be completed over the next year. *Program Integration and Implementation* includes the ETAP Instructor Certification School (ICS). ICS is a four-day program designed to teach physical training leaders (NCOs) how to implement and effectively instruct ETAP at the unit level and is based on the Army concept of "train-the-trainer". The final step: *Monitor and Determine the Effectiveness of the Program* will test the effectiveness of ETAP to mitigate musculoskeletal injuries and optimize physical readiness and performance. A parallel approach has been adopted to include injury surveillance both during garrison and deployment and prospective interval testing of laboratory, performance, and APFT variables.

To date, 952 Soldiers have participated in ICS. Soldiers enrolling in ICS are non-commissioned officers (NCO) who regularly instruct morning physical training. Part of each graduate's responsibility is to teach ETAP to other Soldiers who are unable to attend ICS and instruct at the unit level. Two NCOs (a senior and junior NCO) per platoon participated. To recruit an equal number of Soldiers from each Brigade and accelerate Division-wide implementation, six to eight ICS sessions (weeks) were scheduled for each Brigade, with the unit assignment based on the Brigade's and Division's pre-deployment training cycle. The goals of ICS include: 1) experience and understand a comprehensive physical fitness program, 2) understand the components and underlying principles of ETAP to effectively adapt it to individual or unit situations, and 3) develop a working understanding of how to implement ETAP with little to no equipment to ensure that the program is deployable. Daily activities over the four-day course allow for participants to achieve these goals through a multifaceted learning approach. The Soldiers were familiarized with the exercises and the program through participation in ETAP training sessions; interactive sessions including traditional lectures and presentations as well as open discussion to ensure proper understanding of the theory behind the program. Proper technique, progressions, and corrections for the exercises, and alternative exercises and/or training that can be employed while still accomplishing the same goals are covered during "hands on" practice sessions to implement and instruct ETAP. A course outline for ICS is summarized in Table 9. Day 1 covered basic exercise physiology, warm-up/cool-down, stretching, anaerobic conditioning, and agility exercises. Day 2 covered nutrition and resistance exercises. Day 3 covered aerobic interval workouts, balance exercises, partner resistance exercises, and proper lifting techniques. Day 4 covered plyometric exercises, IBA workouts, medicine ball exercises, landing techniques, and PT program design. At the completion of ICS, students received the eight week ETAP workout cards along with the corresponding DVD. The DVD contains all of the lecture slides, a written description and videos of all exercises performed, exercise progression guidelines, perceived exertion and heart rate guidelines as well as information to develop alternative ETAP exercises given the deployment environment. The validated 8-week ETAP program has been extended according to each Brigade's pre-deployment training schedule with repeated cycles of increasing intensity. The training cycles contain the same principles by which the 8-week model was developed, but modified the progression of each training modality. The weekly training format is identical with individual days dedicated to different components of fitness, yet allowing for combat focus training. Based on ICS enrollment, 40 Soldiers per platoon, and an instructor to Soldier ratio of 2:40 or 1:20 per platoon, approximately 19,500 Soldiers have been exposed to ETAP at the unit level. This ratio allows for adequate supervision of Soldiers performing ETAP, ensuring that proper technique and progressions are maintained. In addition, quality control audits are conducted by personnel from the University of Pittsburgh, ensuring proper delivery of ETAP by the NCOs to their respective units and allowing for implementation-related questions to be answered and assessment of exercise performance/technique of the Soldiers at the unit level.

To date, 1478 out of a projected 2000 Soldiers have been enrolled in step six, *Monitor and Determine the Effectiveness of the Program*. Soldiers from a representative Brigade performing ETAP are participating in this aim as the experimental group while Soldiers from a separate Brigade which performs comparable tactical operations and is deployed to a similar location/environment are serving as the control group. To participate, Soldiers must spend a minimum of six months at garrison and 12 months deployed during participation. History of injuries prior to the study start date will be used to compare the frequency of injuries at baseline between the ETAP and regular Army PT groups. The proportion of subjects with unintentional injury will be compared between the ETAP group and the regular Army PT group at the end of 18 months of follow up, by Chi-square tests. A Kaplan-Meier survival analysis will be used to compare time to injury between the two groups. A Cox regression will be used to adjust for variables such as gender, age, number of months of exposure to the ETAP, years of service, and deployment status.

Summary

The purpose of this paper was to describe the last three steps of the injury prevention and control model: *Design and Validation of the Interventions, Program Integration and Implementation, and Monitor and Determine the Effectiveness of the Program* as studied with the 101st Airborne Division (Air Assault). ETAP is a research-based, comprehensive program developed specifically for the 101st Airborne Division (Air Assault) based on inherent injury epidemiology, task and demand analyses, identification of suboptimal physical and physiological characteristics compared to an athletic benchmark, and previously established injury risk factors.

Although it has been demonstrated that ETAP can positively impact physical readiness in a controlled trial, prospective injury surveillance must occur to properly and accurately assess the effectiveness of ETAP to reduce the risk of unintentional musculoskeletal injuries in Soldiers performing ETAP. Additionally the prospective analysis of performance is necessary to determine the effectiveness of ETAP to optimize physical readiness when delivered by the Soldiers of the 101st Airborne Division (Air Assault). The effectiveness of ETAP to be implemented into the Division and resultant mitigation of unintentional musculoskeletal injuries and performance optimization is ongoing and will be completed over the next year.

The application of the public health model of injury prevention and control is an effective tool to scientifically develop and implement injury prevention and performance optimization programs for the tactical athlete, regardless of tactical demands. The research model described for the development of ETAP and 101st Airborne Division (Air Assault) is adaptable to culturally-specific units and driven by the task and demand analysis by which the entire injury prevention and performance research model can be implemented within different Special Operations Forces units.

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