Adaptations to a New Physical Training Program in the Combat Controller Training Pipeline

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Abstract

Objectives: The United States Air Force combat controller (CCT) training pipeline is extremely arduous and historically has a high attrition rate of 70 to 80%. The primary objective of this study was to evaluate the impact of incorporating a 711 Human Performance Wing (HPW) / Biobehavior, Bioassessment, and Biosurveillance Branch (RHPF)-developed physical fitness-training program into the combat controller (CCT) 5-level training physical fitness program. **Methods:** One-hundred-nine CCT trainees were tested and trained during their initial eight weeks at the 720th Special Tactics Training Squadron (STTS) at Hurlburt Field. Modifications to their physical training program were principally aimed at reducing overtraining and overuse injury, educating trainees and cadre on how to train smarter, and transitioning from traditional to "functional" PT. A battery of physiological measurements and a psychological test were administered prior to and immediately after trainees undertook an 8-week modified physical fitness training program designed to reduce overtraining and injury and improve performance. We performed multiple physical tests for cardiovascular endurance (VO_2max and running economy), "anaerobic" capacity (Wingate power and loaded running tests), body composition (skinfolds), power (Wingate and vertical jump), and reaction time (Makoto eye-hand test). We used the Mental Toughness Questionnaire 48 (MTQ-48) for the psychological test. **Results:** We observed several significant improvements in physical and physiological performance over the eight weeks of training. Body composition improved by 16.2% ($p<0.05$). VO2max, time-to-exhaustion, and ventilatory threshold were all significantly higher after implementation of the new program than before it. We observed strong trends towards improvement in work accomplished during loaded running ($p = 0.07$) and in average power per body mass during lower body Wingate ($p = 0.08$). Other measures of lower body power did not change significantly over the training period, but did show mild trends towards improvement. Upper body average and peak power per kilogram of body mass both improved significantly by 5.8% and 8.1%, respectively. Reaction time was significantly better post-training as demonstrated by a 7% improvement during the reactive test. Reactive accuracy also improved significantly with the post test accuracy percentage jumping from 61% to 76%. Furthermore, overuse injuries, a major source of attrition fell by a dramatic 67%. **Conclusions:** The modifications resulted in significant improvement in trainees' graduation rate. In the eight classes prior to implementation of these changes, average CCT graduating class size was nine trainees. For the eight classes following the changes, average CCT graduating class rose to 16.5 trainees, an increase of 83%. Due to its success, STTS leadership expanded the modifications from the eight weeks prior to CDS to include the entire second year of the pipeline.

Introduction

Historically, the 24-month CCT training pipeline has had an attrition rate over 70%. Primary reasons for this attrition include self-initiated elimination, failure to meet physical and academic standards, and overuse injuries. With increased demand for CCTs, there has been a renewed effort to reduce this rate. The 720th Special Tactics Training Squadron (STTS) is responsible for the second half of the two-year pipeline, which includes Combat Dive School (CDS). CDS is one of the most physically demanding phases of the pipeline and consequently has a very high washout rate. We believed that this high attrition rate could be corrected by the incorporation of advanced physical training methods.

Members of the 711 HPW/RHPF found trainees to be chronically over trained by the time they arrived at STTS. During the previous 12 months, trainees had attended several different schools, all of which physically trained them extremely hard, without regard for what physical training (PT) they had accomplished in the previous school or what they would do in the next school. Further, trainees were not recovering from these demands optimally due to poor nutrition and hydration practices. Finally, many of the training methods employed throughout the pipeline were outdated, non-periodized, and non-functional. The purpose of this study was to evaluate the impact of incorporating an advanced, non-traditional physical fitness training program into the combat controller (CCT) 5-level training physical fitness program. Our hypothesis was that revisions to the PT program, principally aimed at reducing overtraining and replacing traditional PT with more functional PT, could lower injury and attrition rates while maintaining or improving physical performance for CCTs in their 5-level training program.

Methods

Participants

One-hundred-nine CCT trainees, ages 19-30, signed institutionally-approved informed consent documents and were enrolled into the study. All trainees had successfully completed the first year of CCT training and had achieved 3-level status as an Air Force Combat Controller.

Facilities

Data collection was performed at the 720th STTS Physical Training Facility located at Hurlburt Field, FL. The STTS is responsible for the 5-level, or advanced skills training, portion of the two-year CCT pipeline, producing operationally-ready combat controllers. Physical testing was incorporated into the pre-SCUBA phase of training, occurring during the first two months of the 12 month program. Test results were quickly analyzed and enabled the prescription of individualized exercise regimens.

Experimental Design

In consultation with STTS cadre, several changes were made in the CCT trainee PT program. These revisions were principally aimed at reducing overtraining and overuse injury, educating trainees and cadre on how to train smarter, and transitioning from traditional to "functional" PT. A battery of physiological measurements were administered immediately prior to and immediately following eight weeks of PT that conformed to these new guidelines. These measures were chosen on the basis of being standard physical fitness parameters, CCT-specific physical attribute indicators, or validated psychological surveys. A battery of physical tests measured cardiovascular endurance (VO_2max and running economy), "anaerobic" capacity (loaded anaerobic endurance treadmill tests), body composition (skinfold measurements), power (Wingate and vertical jump), and reaction time (Makoto tower test.) Each test was conducted using a standardized protocol. Psychological characteristics were explored through use of the Mental Toughness Questionnaire – 48 (MTQ 48).

Specific Program Modifications

Elimination of the weekly physical evaluation. Prior to our intervention trainees' physical fitness was evaluated weekly with a timed 1,500 to 3,000m surface swim, chin-ups, push-ups, sit-ups, and a three to six mile run. (Distances were determined by what week of training they were in and generally increased throughout a training cycle). Being that it was an evaluation, trainees tried to max perform this test. This practice was not necessary to maintain an accurate gauge of trainee fitness and was contributing to overtraining.

Creation of a nutrition and hydration class. Apart from being told to drink copious amounts of water, trainees had little education regarding optimizing recovery through hydration and nutrition. We designed and implemented a short class that explained the benefits of pre-hydrating, using sports drinks instead of water, maximizing glycogen stores by eating a diet rich in complex carbohydrates, and replenishing glycogen immediately after workouts.

Cadre education. Cadre design and lead PT for the trainees. Much of the PT being done had not changed in over 20 years. We created and implemented a Train-the-Trainer Course at Hurlburt Field. The four and a half-day course was divided evenly between academic training and hands-on practice on the most effective ways to physically train CCTs.

Creation of the Combat Athlete Training Cell at STTS. Prior to our interventions, STTS cadre directed trainee PT as an additional duty. As a result, it was difficult for them to allot the time necessary to create a truly comprehensive PT plan for the trainees. Following AFRL's suggestion, the STTS formed the Combat Athlete Training Cell with two instructors that made CCT trainee fitness their primary mission.

Creation of a state-of-the-art PT center. CCT trainees used to exercise at the base fitness center or in a small weight room in their dormitory. In 2008, following RHPF guidance, the STTS opened a new building that included a 2,500 sq ft PT area with state-of-the-art equipment, including tools for VO_2max, Wingate, and reaction time tests. Then in 2009, the STTS opened a 9,600 sq ft, sheltered, turf-floored, outdoor training area. Such facilities have allowed for the incorporation of all types of effective functional exercises.

Revision of the PT plan. The majority of traditional, long distance running for cardiovascular fitness was replaced by interval running and agility training (e.g., ladder drills, hurdles, cone drills, etc.) with only occasional long runs. Average miles run per week were cut by approximately 50% while intensity of the runs increased. Traditional bodybuilding-type resistance training (e.g., bench press, bicep curls) was replaced by functional strength training. Functional strength training focuses on power and explosiveness and incorporates closed-chain, multi-joint, standing exercises (e.g., squats, push-presses, kettlebell swings), as opposed to the single joint, externally stabilized motion of many bodybuilding exercises.

Addition of athletic trainer visits. Prior to the current study, trainees with minor injuries often ignored or denied them, until they developed into chronic and/or serious injuries. At that point they were forced to see the flight surgeon and were often removed from training. As part of this comprehensive revision, the 720th Special Tactic Group (the parent organization of the 720th STTS) hired an athletic trainer who visited CCT trainees at the STTS twice per week. The trainer performed a sort of "triage," providing treatment and advice to those with minor injuries and ensuring those with major injuries were quickly seen and treated by the flight surgeon. Additionally, STTS cadre allowed those with minor injuries to cross-train or to actively rest when needed without negative repercussion.

Changed policy for injured trainees. Previously, trainees who suffered minor injuries were "set backs" who were forced to restart training from the beginning. This policy was changed so that trainees with minor injuries were provided a specific PT/rehab program and allowed to continue to train and improve, then rejoin their class. If they couldn't keep up with their own class then they were allowed to join a following class at or near the point at which they were injured.

Test Procedures

Body composition. Subjects' skinfolds were taken by Lange calipers (Cambridge Instrument, Cambridge, MD) at the standard chest, abdomen, thigh, subscapular, axillary, tricep and suprailliac sites. Three samples were taken and the average measure was used as the final value. The sum of these sites was used to determine body density.[1] Body fat percentage was computed from body density using the Siri equation.[2]

Cardiorespiratory endurance. Maximal oxygen uptake (VO_2max) and running economy protocols were conducted on a Woodway DESMO treadmill (Woodway USA, Waukesha, WI). Each subject was fitted with a harness and a facemask to collect expired air for the Parvo Medics' TrueOne 2400 metabolic measurement system (Consentius Technologies, Sandy, UT). Subjects wore a Polar heart rate monitor transmitter (Polar Electro, Inc., New York, NY) around the chest to measure heart rate (HR) response throughout the warm-up, test, and recovery phases of the protocols. After a one-minute rest period to verify transmitter communication, subjects performed a two-minute walk at a 2.0 mph. Upon completion of the two-minute walk, treadmill speed increased to 7.0 mph at 0% grade. This speed and grade were maintained for three minutes to test for 7.0 mph running economy. Following that stage, the 7.0 mph speed was maintained while the grade increased by 2% increments every minute until it reached a 10% grade, after which it increased by 1% each minute until it reached a 15% grade or until subjects reached volitional fatigue. If subjects did not reach volitional fatigue at the maximum treadmill grade of 15 %, the treadmill speed increased by 0.5 mph every minute until the subject reached volitional fatigue. Once volitional fatigue was reached, the treadmill's speed slowed to a 2.0 mph pace at 0% grade to induce active recovery until his heart rate dropped below 120 bpm. At the one-minute recovery stage, the subject received a finger stick for blood lactate collection (10microL). These one-minute post-test lactates were analyzed using the Lactate Pro system (Arkray, Inc., Kyoto, Japan). Results of this test were also used to estimate ventilator threshold (VT). VT was determined to be the point where there was a simultaneous deviation from linearity in ventilation and an increase in VE/VO2.[3]

Battlefield Airman Test. The Battlefield Airman Test (BAT) is an anaerobic endurance test of loaded running, designed by the investigators specifically for this population using the Woodway Force 2.0 human powered treadmill. Subjects were fitted with a Polar heart rate monitor transmitter that monitored HR throughout the warm-up, test, and recovery phases. First, the subjects performed a two-minute warm-up on a Woodway Desmo treadmill striving to achieve a warm-up heart rate of 130-140 bpm. A Woodway waist belt was donned following the warm-up and attached to a force transducer on the rear post of the Force treadmill. The treadmill was preprogrammed with five pounds of resistance internally loaded to the treadmill belt to provide load and to help alleviate any balance issues. Subjects started to jog and then were given five seconds to achieve a self-selected speed above 7.0 miles per hour. The test continued until the subject could no longer maintain a speed greater than 7.0 mph. All subjects were given one warning to increase their speed if they dropped under 7.0 mph, and the test was terminated if they couldn't increase their speed or when the subject dropped below 7.0 mph for the second time.

Wingate Tests. Each subject accomplished an upper body and lower body Wingate anaerobic test (WAnT) on a Monarch 894E Ergomedic Wingate Test Ergometer (Monarch, Seattle, WA). These instruments are specially designed systems with instantaneous loading and braking features. For the lower body test, the seat height was adjusted so that no more than five degrees of knee flexion was present when the leg was fully extended. Each subject performed a three to five-minute warm-up period striving to achieve a warm-up heart rate of 130-140 bpm, including two or three five-second high revolution spins. Resistance for the test was set at 7.5% (lower body) and 5.0% (upper body) of the subject's body weight within a 0.1 kg resolution of resistance range. A Polar heart rate monitor transmitter monitored HR throughout the warm-up, test, and recovery phases. The WAnT consisted of a countdown phase and a 30-second (legs) or 15-second (arms) all-out pedaling phase. During the first five seconds of the countdown the subject pedaled at a comfortable cadence. At that point, subjects began pedaling at maximum speed at 33% of peak resistance. When subjects' rpms exceeded 150, test resistance was added instantaneously by dropping the weight rack. At one-minute post completion, subjects received a finger stick for blood lactate collection (10microL). These one-minute post-test lactates were analyzed using the Lactate Pro.

Reaction time. Eye-hand reaction speeds were measured on the Makoto Sports Arena (Makoto USA, Centennial, CO) in reactive and proactive modes. A one minute rest was given between tests. Each test was performed twice and the better of the two scores was recorded. In the proactive test, the targets on a single tower remained activated until hit by the subject. The results of the proactive test were the average time to hit each target. In the reactive test, targets on a single tower only remained active for 0.53 seconds. If the subject did not hit the target in the allotted time, then the occurrence was recorded as a miss. The results of this test were the percentage of targets hit and the average time to hit each target.

Vertical jump. A Vertec (Questec Corp., Northridge, CA) vertical measuring device was used to measure vertical jump height. Standing height of the subject was taken with one arm fully extended upward. Then the subject was asked to jump up to touch the highest possible vane while keeping both feet on the ground before starting the jump. Countermovement was allowed but approach steps were not. The subject continued jumping, with brief rest periods between jumps, until the peak height stalled for two consecutive jumps. Jump height was the difference between standing height and peak jumping height.

Mental toughness. The Mental Toughness Questionnaire 48 (MTQ 48) assesses a subject's ability to withstand pressure in a range of environments.[4-5] This 48-question written test measures the different elements of performance related characteristics in four core components: challenge, control, commitment, and confidence. Each subjects' answers were input into the MTQ 48 database and used to create a Coaching Report describing each subject's level of mental toughness. This Coaching Report provides trainers and coaches with a narrative about an individual's leadership style and offers coaching suggestions that will help the trainer or coach to better understand their trainee or team. The subjects completed the questionnaire both at the beginning and at the end of their participation in the study.

Statistical Analyses

Independent t-tests were used to compare results between testing sessions. An alpha value of less than 0.05 was used in all comparisons to indicate statistical significance.

Results

We observed several significant improvements in physical and physiological performance over the eight weeks of training. Body composition improved by 16.2% ($p<0.05$). VO2max, time-to-exhaustion, and ventilatory threshold were all significantly higher after training ($p<0.05$). Table 1 displays pre and post training means for cardio-respiratory endurance parameters and body composition.

Table 1. Body composition and maximal oxygen uptake results.

	Bodyfat (%)	VO_2max (mL/kg/min)	Ventilatory Threshold (L/min)	Time-to-Exhaustion (sec)	Peak Heart Rate (bpm)	Ventilatory Threshold Heart Rate (bmp)
Pre Mean	12.39	58.90	3.91	826	196	181
Pre SD	3.08	4.58	0.39	65.62	8.08	8.72
Post Mean	*10.78	*61.40	*4.06	*858	195	180
Post SD	3.37	4.76	0.43	70.11	8.63	9.40

*indicates significantly different from Pre to Post ($p<0.05$)

We observed strong trends towards improvement in work accomplished during the BAT ($p = 0.07$) and in average power per body mass during lower body Wingate ($p = 0.08$.) Other measures of lower body power did not change significantly over the training period. Upper body average and peak power per kilogram of body mass both improved significantly by 5.8% and 8.1%, respectively ($p<0.05$). A summary of "anaerobic" capacity and power results is displayed in Table 2.

Table 2. "Anaerobic" (Battlefield Airman Test, Wingate tests, Vertical Jump) results.

	BAT distance (m)	BAT Work (J)	Lower Wingate Peak Power (W/kg)	Lower Wingate Mean Power (W/kg)	Upper Wingate Peak Power (W/kg)	Upper Wingate Mean power (W/kg)	Vertical Jump (cm)
Pre Mean	267.02	9.40	11.39	9.27	8.06	6.37	62.25
Pre SD	75.97	2.29	1.65	0.83	1.36	0.79	8.53
Post Mean	284.89	10.03	11.62	9.50	*8.71	*6.72	62.89
Post SD	69.01	2.35	1.33	0.89	1.22	0.66	7.59

*indicates significantly different from Pre to Post ($p<0.05$)

Reaction time was significantly better post training as demonstrated by a 7% improvement (improved reaction time by 0.04 s) during the reactive test. Reactive accuracy also improved significantly with the post test accuracy percentage elevated from 61% to 76%.

Table 3. Makoto reaction time results.

	Makoto Proactive (s)	Makoto Reactive (% hit)
Pre Mean	0.57	0.61
Pre SD	0.06	0.17
Post Mean	*0.53	*0.76
Post SD	0.06	0.18

*indicates significantly different from Pre to Post ($p<0.05$)

We collected a random sample of 15 trainees and did not see a change (i.e., average change = 0.065) in their Mental Toughness responses (most had no changes or changes of +1 or -1). Table 4 shows the results for each of the core components of the MTQ 48 and their overall mental toughness.

Table 4. Mental Toughness Questionnaire 48 results.

	Overall Mental Toughness	Challenge	Commitment	Control	Confidence	Average less Overall Mental Toughness
Mean	7.9	7.0	8.0	7.3	7.5	7.3
SD	1.6	1.8	1.6	1.8	1.7	1.3

Table 5. Peak lactate values.

	VO2 max Peak Lactates ($mmol \cdot L^{-1}$)	BAT Peak Lactates ($mmol \cdot L^{-1}$)	Upper Body Wingate Peak Lactates ($mmol \cdot L^{-1}$)	Lower Body Wingate Peak Lactates ($mmol \cdot L^{-1}$)
Pre Mean	12.88	13.60	9.18	10.72
Pre SD	2.80	3.0	3.91	3.21
Post Mean	13.12	13.2	8.35	9.6
Post SD	2.61	2.7	2.73	2.2

Peak lactate values (Table 5) were not significantly different from pre to post, but did consistently trend lower following the anaerobic tests after eight-week training period, while work performed increased, indicating greater mechanical efficiency by the trainees after training.

Figures 1 through 9 provide graphic representations of the physiological changes that occurred throughout the eight weeks of training. Figure 1 shows the significant 16.2% improvement in body composition. Figure 2 shows the 4.23% increase in VO_2 max test at the end of the eight weeks, while Figures 3 and 4 show the improvement in reaction time both in the decrease in seconds to hit the target and an increase in their accuracy of hitting targets. Figures 5, 6, and 7 show the changes in their anaerobic test performance.

Figure 1. Body Composition Results.

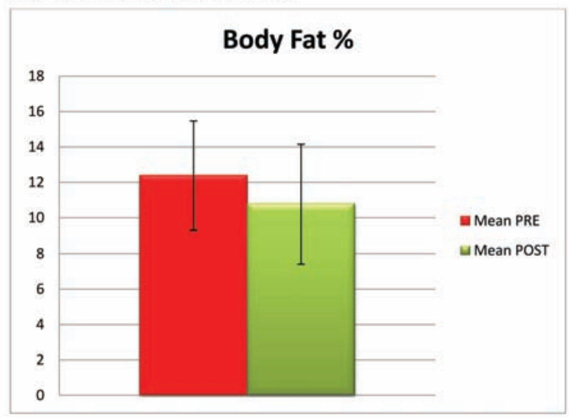


Figure 2. VO2max Test Results.

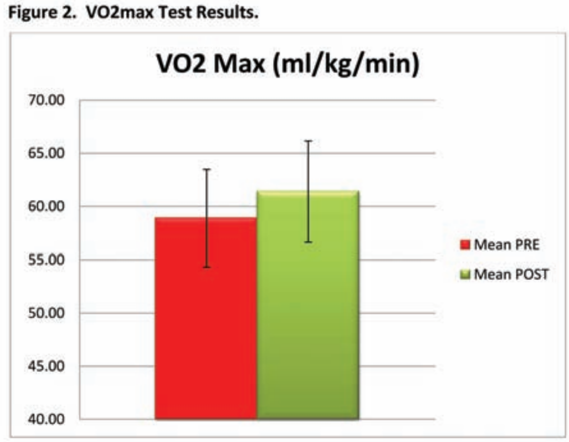


Figure 3. Makoto Proactive Test Results.

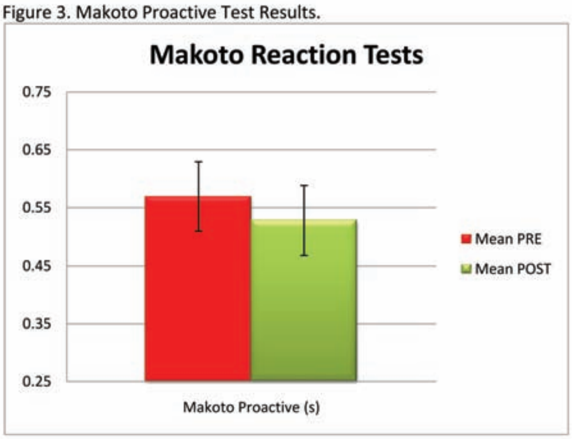


Figure 4. Reactive Makoto Test Results.

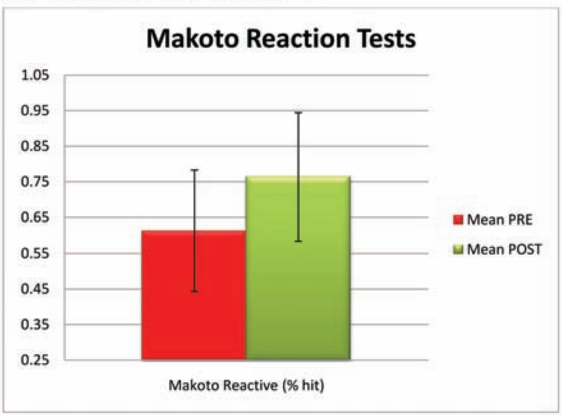


Figure 5. Battlefield Airmen Test Results.

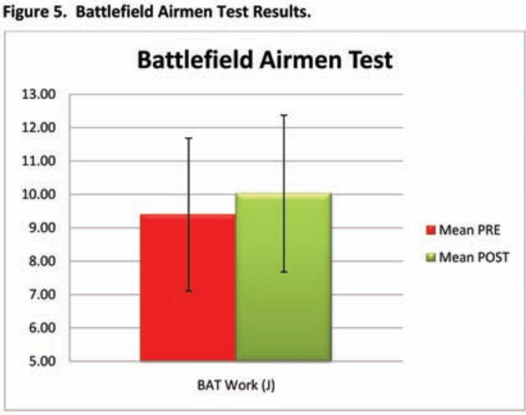


Figure 6. Battlefield Airmen Test Distance Results.

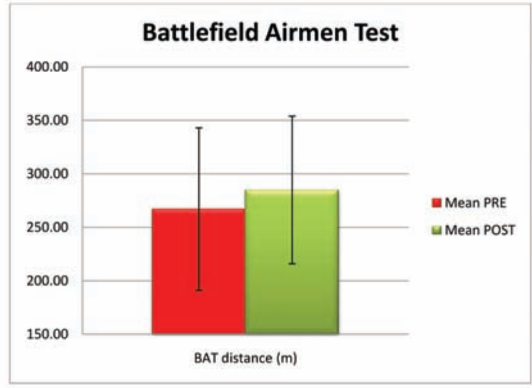


Figure 7. Post Peak and Average Lower Body Wingate Results.

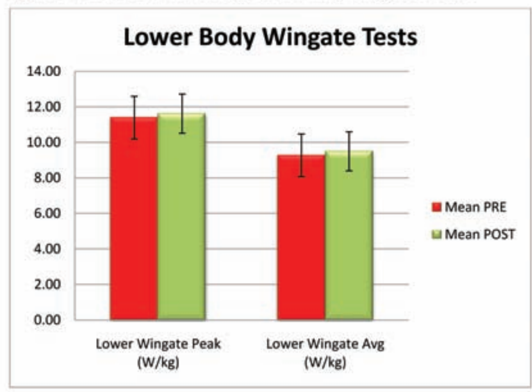


Figure 8. Peak and Average Upper Body Wingate Results.

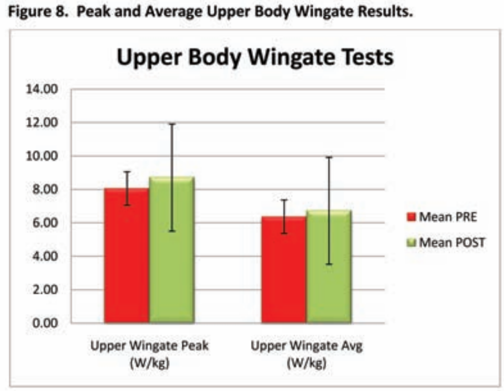
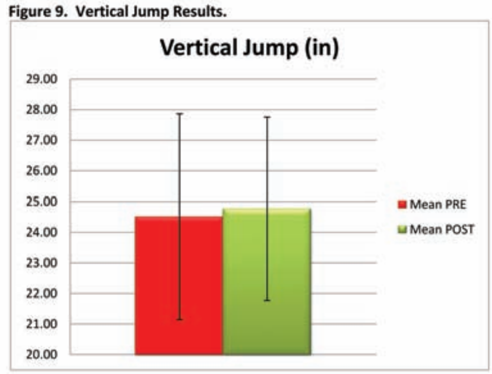


Figure 9. Vertical Jump Results.



Discussion

The implementation of the new physical training plan resulted in significant improvements in trainees' performance and graduation rate. These improvements were so dramatic that STTS leadership expanded the modifications from the eight weeks prior to CDS to include the entire second year of the training pipeline. In the eight classes prior to implementation of these changes, average CCT graduating class size was nine trainees. For the eight classes following the revisions, average CCT graduating class jumped to 16.5 trainees, an increase of 83%. Much of that increase was due to more trainees exceeding physical standards for progression, particularly at Combat Dive School.

Most of the changes we made to the physical training plan were two-fold: reduce overtraining and replace traditional exercises with operationally functional exercises. Functional exercise may be defined as physical training designed specifically to improve the performance of specific occupational or athletic tasks. It has become popular in sport training due to anecdotal reports of its success. The concept of using functional fitness to improve military performance was first discussed by Mercer and Strock.[6] They primarily advocated functional training for its potential for injury reduction, but also logically posited that designing physical training plans from an occupational demand perspective could benefit performance in the field. Many of their recommendations have recently been adopted by the U.S. Army.[7]

In one of the few published investigations of functional training, Spennewyn compared subjects who performed 16 weeks of fixed resistance training, with those who performed functional "free-form" resistance training, along with a control group.[8] The control group did not show significant improvement in either strength or balance. The fixed group increased strength 57% from baseline while the free-form group increased strength 115% from baseline, a statistically significant difference. Balance improved 49% in the fixed group versus 245% in the free-form group, again a statistically significant difference. In the case of CCTs, we hypothesized that long distance linear running, pressing movements, and other traditional exercises had low functional value for CCTs and therefore we replaced them with what we considered to be functional training for CCTs: short distance high intensity running, agility drills, and free-form, multi-joint resistance exercises.

Our results showed that replacing traditional training with functional training was very effective. We observed significant increases following the new program in nearly every physiological variable we measured. Body composition, VO_2max, time-to-exhaustion, ventilatory threshold, reaction time and accuracy, and upper body power all improved significantly after implementation of the new program. Those few areas that did not show statistically significant improvements all trended toward improvement. These improvements are even more meaningful when considering that the trainees had been participating in a demanding physical training program for over one year immediately prior to undergoing this functional training period.

Notably, because the VO_2max test was a treadmill running test it seemed possible that due to the principle of specificity of training, the program's reduction in running might actually decrease performance on this test. However, that was not the case as running-derived VO_2max increased by an average of 2.5mL/kg/min. This data supports that of Sporis et al. who demonstrated that in trained athletes, eight weeks of linear running did not elicit improvements in cardio-respiratory measures, whereas high intensity technical drills did elicit significant improvements.[9] This also supports results in our own lab where in a six-week comparison of agility training versus linear running, VO_2max increased by 6.1ml/kg/min ($p<0.05$) in the agility group, whereas the running group increased by only a non-significant 1.7ml/kg/min.

Another large part of the dramatic increase in graduation rate was due to a decrease in the injury rate with the new program. After implementation of the new program, overuse injuries decreased by a staggering 67%. The new program dramatically eliminated overtraining in trainees. We believe several of the changes implemented contributed to this reduction. Overtraining has clearly been demonstrated to contribute to overuse injuries.[10-11] Smith has suggested that excessive training causes repetitive tissue trauma, either to muscle and/or connective tissue and/or to bony structures, resulting in chronic inflammation and leading to injury.[10] Overtraining can also produce neuroendocrine irregularities, immune system suppression, and psychological problems, all of which could cause a trainee to fail to progress in training.[11]

We suggest that conventional training, particularly daily long distance linear running, may be a prime cause of injury in CCT trainees. Mercer and Strock examined 36 months of data for U. S. Navy Special Operators that included over 5000 rehabilitation visits for causative activity.[6] They discovered that conventional physical training was identified as the primary cause of rehabilitation referrals and direct complaints. We further suggest that this increased risk of injury is incurred without providing significant improvements in fitness. Knapik et al. conducted an investigation in which one group of Soldiers substituted agility drills, high intensity intervals, and flexibility exercises for much of their conventional linear running and calisthenics over a nine-week period.[12] They observed that this modification lowered the injury rate by 33% while producing a slightly better pass rate on the Army Physical Fitness Test than a conventional group. The results of the current study strongly support these hypotheses.

Bullock et al. recently completed an in-depth review of physical training related injuries in the U.S. Department of Defense.[13] They reviewed 40 physical training related injury prevention strategies and found strong evidence for six of them. The injury prevention strategy with the most evidence-based support was the prevention of overtraining. The next most supported strategy was to perform agility training. They found solid evidence that injuries are reduced by increasing the proportion of exercise time devoted to exercises that vary musculoskeletal stress in multiple planes of motion and improve coordination, agility, and kinesthetic sense. Our replacement of linear running with agility training directly follows this strategy and certainly contributed to the large reduction in injuries observed here.

Another of the strategies Bullock et al. found to be well supported was for trainees to optimize recovery by consuming proper nutrients within one hour of high-intensity exercise.[13] There are several examples of the benefits of this strategy found in exercise nutrition literature.[14] Much of our education of the CCT cadre and trainees emphasized this strategy, and it is likely that the implementation of better nutrient replenishment was a factor in the reduction in injuries.

The improvement in fitness levels which occurred under the revise program likely also contributed to a reduction in injuries. As noted above, fitness improvements were clear and, in some cases dramatic. Previous research has clearly indicated a strong negative association between fitness and risk of attrition in military training and between fitness and injury during athletic training.[15,16]

Although difficult to quantify, it is probable that the informal triage the athletic trainer provided was also an important factor in injury reduction. Such intervention likely identified and successfully treated some potentially disruptive injuries before they reached the point of limiting performance. Future studies may wish to attempt to better define such success.

There was little change between the pre-test and post-test responses for mental toughness; most trainees' scores had no change or changes of +1 or -1. This change was not unexpected as our revisions to the training plan did not specifically address mental toughness. Furthermore, trainees lacking high levels of mental toughness were unlikely to complete the first year of the grueling CCT training pipeline to make it to the point of training where we intervened. There is evidence of a strong relationship between physical fitness and mental toughness. Previous research has indicated that superior mental toughness is highly related to successful sports performance.[17-18] Moreover, Crust and Clough have demonstrated a significant correlation between mental toughness and physical endurance.[19] Future studies may wish to compare CCT trainees' mental toughness scores at the beginning of the training pipeline to later stages of the pipeline.

Conclusion

The primary objective of this investigation was to evaluate the impact of incorporating an advanced, non-traditional physical fitness training program into the combat controller (CCT) 5-level training physical fitness program. We observed multiple significant improvements in physical and physiological performance of CCT trainees over the eight weeks of training following our modifications to training. The modifications also resulted in significant reductions in PT-related injuries. These factors combined to nearly double the graduation rate. With a training cost of nearly $250,000 per graduate and the continuing high demand for qualified CCTs, increasing graduation rates is crucial. We believe other combat athlete communities (e.g., other CCT schools, pararescuemen, tactical control parties, etc.) would benefit from adopting the practices executed in this investigation.

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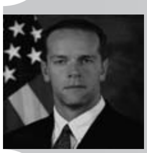

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