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Comparative Study of Army Physical Readiness Protocol TC 3-22.20 vs. ROTC CrossFit Training

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Comparative Study of Army Physical Readiness Protocol TC 3-22.20 vs. ROTC CrossFit Training

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Abstract

The purpose of this research study was to compare two premier training programs' effectiveness in college-aged ROTC cadets at the College at Brockport. Ten volunteer participants, five from each test group, were asked to complete a battery of tests, including Biodex System II Isokinetic Dynamometer, Sit and Reach, Push-Up to Failure, and Forestry Step Test, to evaluate their lower body strength, flexibility, upper body strength, muscle endurance, metabolic, and flexibility improvements after training for four weeks. Cadets (n=5) in their first or second year of ROTC (19.6±0.54), known as MSI's and MSII's, using the TC 3-22.20 Military Physical Readiness Training Protocol were pre-tested the first week in April 2012, and again the last week in April 2012. Similarly, third year cadets (n=5), MSIII's training with the CrossFit program were pre and post-tested in the same weeks as the TC 3-22.20 group. The testing results from pre and post tests from each test group were compared in an attempt to determine effectiveness of each training regimen. The test results for the Biodex System II, lower body strength evaluation, show an increase (16.92%) in average concentric flexion strength at the knee of the dominant leg for the TC 3-22.20 test group (48.26ft-lbs to 57.18ft-lbs). The CrossFit group increased (2.40%) from pre-test to post-test, concentric flexion strength at the knee of the dominant leg (56.68ft-lbs to 58.06ft-lbs). Using the Biodex, concentric average strength of extension at the knee was increased in the TC 3-22.20 group (6.40%) and CrossFit group (4.40%). The TC 3-22.20 group increased average strength of extension at the knee (113.52ft-lbs to 121.02ft-lbs), while the CrossFit group showed average increase (103.42ft-lbs to 108.02ft-lbs). Average flexibility values negatively changed in the TC 3-22.20 group (-47.8%), and the CrossFit group (-11.0%). Push-ups to failure average percent change (-37.2%) in TC 3-22.20 total group decrease (44.0 to 30.2). Push-up to failure count average in CrossFit group positively changed (5.79%). Average push-ups to failure increased (73.8 to 78.2). Estimated 1-RM average, TC 3-22.20 group (-31.2%) decreased (164.7lbs to 120.2lbs) overall. CrossFit test group 1-RM average positively changed (4.05%) corresponding to an increase (239.0lbs to 248.9lbs). Finally, estimated VO_2 Max average was decreased (-40.0%) in the TC 3-22.20 test group (46.8ml/kg/min to 31.2ml/kg/min). Estimated VO_2 Max average values in the CrossFit group changed (1.27%) and an increase of (47.1ml/kg/min to 48.0ml/kg/min). Paired T-tests were performed on each data set. The results of this study produced little statistically significant data to scientifically suggest one training program to be more effective than its counterpart in this four week trial. T-test results yield a p-value (0.052) indicating a statistically significant decrease in estimated VO_2 Max for TC 3-22.20 test group. More research is required to accurately determine if enhanced effectiveness results from training protocol TC 3-22.20 or CrossFit in college-aged ROTC cadets.

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Introduction

Regular Physical Training (PT) and enhanced physical fitness are necessities for those who serve in the military. Elite athletes receive state of the art, highly specialized training in order to be physically fit, successful in their particular sport. Elite athletes of modern times are trained specifically to optimize their own performance and create a degree of advantage over their opponents. Military personnel however, in various instances, are trained insufficiently in comparison to the import of their own success. Military success is evaluated in several ways; safety, survival, mission completion, and national security.[3, 4,9,10] Soldiers benefit heavily from good physical health and physical training. Physical training allows soldiers to respond and cope with emergency situations, decreases injury rates, improves morale, also improves focus for sedentary job performance.[3,4,7,8-10,] In short, soldier's success is a matter of life and death. Still elite athletes often receive superior specialized training and are more prepared for their specific sporting events than their military counterparts. Historically, the physical demand and training needs of soldiers have provided ample rational for focused efforts toward physical fitness.[4,9] In the recent past many have taken notice of a gradual training disparity between elite athletes and tactical athletes, causing a necessary positive shift in the technology and specialized training developed and offered to our service men and women.

Past military training techniques have commonly been developed for minimal applications in which soldiers could remain "fit" or continue training regardless of their location or resources. Standard body weight exercises like push-ups and sit-ups were the foremost exercises along with distance running. Body weight or "partner-resisted exercise" was commonplace among United States military outfits.[9,10] These training techniques are beneficial in that they can be employed easily and facilitated to large numbers with little or no necessary equipment. In modern times however, these training principles have been shown to have some inadequacies and can result in elevated incidences of unintentional muscular-skeletal injuries. In 1992, 31% of all U.S. Army hospitalizations were due to musculoskeletal conditions and injuries.[7] The majority of these injuries were non-combat related musculoskeletal injuries, rather they occurred during recreational activities, sports, and lifting or moving equipment.[7, 8] Preventable injuries such as these cost military and defense companies large sums of money each year, not to mention the wasted duty time spent in recovery in which soldiers are ineffective. Modern bio-mechanical research technology offers a new perspective in identifying injury risk for athletes including tactical athletes such as soldiers.[4, 9] This information becomes invaluable when combined with specified training techniques as it allows for maximal adaptations and significantly increases strength at anatomical weak points that are prone to injury.

Research studies have uncovered compelling evidence to suggest that in order to improve soldier success and increase injury prevention; some deviations from "traditional physical training techniques" are advantageous.[1,3,5-8] The University of Pittsburgh Neuromuscular Research Laboratory, in conjunction with the Department of Defense, tested soldiers, resulting in identification of some fundamental demands of the tactical athlete.[5-8] The adaptations and requirements of training for a tactical athlete are diverse. In a second phase of this research the University of Pittsburgh developed the Eagle Tactical Athlete Program (ETAP) geared toward

addressing the identified issues in the previous study. The result, improvements in several tests for strength, flexibility, performance, physiology, and the APFT compared to current physical training.[7,8] Using some information from the University of Pittsburgh's research a novel push for physical combat readiness has been the main focus of military physical training in the past two or three years. The Headquarters Department of the Army released a new report, August 2010, detailing improved training procedures, Army Physical Readiness Training TC 3-22.20.[10] In an effort to better support those that serve in the armed forces research similar to the University of Pittsburgh's studies is necessary to maintain national security, soldier safety, and save military lives.

Despite the immense scope of research conducted at the University of Pittsburgh, another novel training approach is beginning to increase in popularity amongst service agencies around the United States. CrossFit, developed by Greg Glassman, is a unique fitness ideology that blends sport and fitness resulting in an extremely effective, exhilarating, yet exhausting exercise experience. "Rising popularity of CrossFit within military and law enforcement circles has led to sufficient institutional and group adoption." [14]

But what is it that makes CrossFit so effective? Glassman has written many articles to address questions and topics such as this in the past decade. According to Glassman, CrossFit is unlike nearly all other training methods.[11-14] CrossFit's success lies in the glaringly distinctive ideology of universal fitness, rather than specified skills. In one example Glassman gives an example of Mark Allen dubbed "the fittest man on earth" by Outside Magazine; he contrasts the physiological skills and abilities of Mr. Allen with an elite decathlete. Glassman's argument is that any decathlete would destroy Mr. Allen in a test of power, strength, or speed.[12] With that in mind CrossFit aims to train athletes for success in nearly any application, by combining training of metabolic conditioning, gymnastics, and power lifting.[11-14] Finally, CrossFit encourages fitness in a competitive atmosphere in which individuals train against themselves and each other for time. The theory being that the competitive nature of mankind elicits an environment in which lack of motivation and training intensity are never in question. CrossFit surely offers a unique approach for training athletes for the unknown and the unknowable.[13]

The College at Brockport's Army ROTC trains college students to be leaders and officers in the Armed Forces after graduating. Consequently this process is quite rigorous due to the magnitude of responsibility that will be placed on these young men and women upon graduation from Brockport. Training must provide these young people with the mental skills necessary to cope with emergencies and lead troops during times of war. Similarly, their physical fitness level must be superior, as it is these future officers that will become leaders amongst their peers. It is no surprise that when the ROTC leadership at the College at Brockport sought to create positive change in the, third year or junior, MSIII cadets' physical training scores and fitness, they adopted an approach similar to CrossFit. Although the, first and second year, MSI's and MSII's still train using a more traditional approach, CrossFit training is gaining attention on a local and national level. When asked about CrossFit PT the MSIII's facial expressions show mild signs of fear and great respect for such a taxing exercise experience.

There is published research evidence that suggests both the Physical Readiness model developed in part by the University of Pittsburgh with the Department of Defense and CrossFit

induce beneficial adaptations for elite as well as tactical athletes. There is less information available that compares two successful training methodologies such as these. Therefore, the purpose of this comparative research study is to test gains in strength, metabolic endurance, and flexibility during a time span of four weeks for those participating in tradition Physical Readiness PT (MSI's and MSII's) vs. CrossFit (MSIII's). It is believed that CrossFit will elicit more dramatic gains in the areas of testing for the given period of time. CrossFit offers a more ideal situation for ROTC cadets to achieve fitness gains while simultaneously competing and building camaraderie with their peers.

Methods

Subjects

Participants from this study were Brockport ROTC cadets between the ages of 18 and 24 years. Two groups of participants were asked to volunteer in this study. One group, the MSI's and MSII's, were college-aged males in their first or second year with the Brockport ROTC. The other group of participants was composed of third year cadets, MSIII's. A total of 10 healthy College at Brockport ROTC cadets participated in this research study lasting a total of four weeks.

Figure 1: Participant Demographics		
	MSI's & MSII's (n=5)	*MSIII's (n=5)*
Age (yrs)	19.6±0.54	21.4±1.51
Height (in)	70.6±2.70	68.0±3.31
Weight (kg)	74.8±4.45	77.4±15.0

Training

Participants from each group, CrossFit and TC 3-22.20 completed a specified training program throughout the duration of the four weeks between pre and post-testing. Slight variations in training protocol of each group were implemented in order to minimize boredom and continuously challenge the cadets, and provide leadership experience to more senior cadets who design and facilitate Physical Training (PT). Basic training procedures are outlined in Figure 2 and Figure 3 below.

Figure 2: MSIII Training CrossFit – "Murphy"		
Advanced	*Intermediate*	*Foundational*
1 Mile Run	½ Mile Run	¼ Mile Run
100 Pull Ups	50 Pull Ups	25 Pull Ups
200 Push Ups	100 Push Ups	50 Push Ups
300 Squats	150 Squats	75 Squats
1 Mile Run	½ Mile Run	¼ Mile Run

The above table illustrates the most common CrossFit workout completed by the Brockport ROTC MSIII Cadets. This workout is meant to be completed in a group setting for time. CrossFit creates a competition aspect that allows for a combination of skill, strength, and camaraderie improvement.

Scores are tracked and displayed for the participants such that individuals strive to better themselves and best their peers. There are three varying levels of difficulty. Routines may be modified or altered in some instances to maximize adaptations and prevent redundancy or boredom.

Figure 3: Traditional Physical Readiness, MSI and MSII Cadets (TC 3-22.20)

Day 1	*Day 2*	*Day 3*
Dynamic Warm-up High knees Lateral Grapevine Butt Kicks 10 Push Ups	Dynamic Warm-up High knees Lateral Grapevine Butt Kicks 10 Push Ups	Dynamic Warm-up High knees Lateral Grapevine Butt Kicks 10 Push Ups
Push-Up, Sit-Up Circuit 60 seconds 45 seconds 30 seconds	4 Mile Run Start: Cooper Hall, Redman Road, Canal Path, Main Street, Return to Cooper Hall	Total Body Circuit • Agility Ladder • Jumping Jacks • Wall Sits • Crunches • Wide Arm Push-Ups • Sit-Ups • Walking Lunges • Burpees • Suicide Sprints • Military Push-Ups
Sprints/Bleachers – 10 min	50 Push Ups, 50 Sit-ups	
Cool Down/Stretch – 5 min	Cool Down/Stretch – 5 min	Cool Down/Stretch – 5 min

The table above shows an average week of the traditional TC 3-22.20 protocol. Cadets perform this training three times per week, every other day, for approximately one hour.

Testing

Participants from each experimental group completed a battery of pre and post tests to determine the effectiveness of each training routine over a four week span of time from the first week in April to the last week in April of the year 2012. The testing for this study was completed during participants' regularly scheduled Physical Training (PT) time in order to limit any possible inconvenience to ROTC requirements and student course schedules. Testing for this study was intended to evaluate muscular strength, endurance, flexibility, and cardiovascular fitness.

Biodex System II

Lower body strength was assessed using a Biodex System II isokinetic dynamometer. The participants were fitted to the instrument prior to testing. Each participant was fitted such that the "axis of rotation" of the knee was in line with the center of the goniometer.[15] Patients were advised to secure the waist seatbelt in order to limit their hip movement. Finally the appropriate leg attachments were fit to the participant for both the dominant and non-dominant leg.

The Biodex instrument was turned on and patient information was input. New patient information was saved and the Biodex was set to the "Isokinetic" operation. Specific range of motion was set for each individual. The goniometer was moved to 90° and the "verify range" option was selected. The subject was asked to move their limb through full range of motion. After, the

participant's leg was moved to the fully extended position and swing arm was locked in place. The leg was relaxed and weighed. Biodex was advanced through the "run test" option. Isokinetic mode was selected. Participants were advised to flex and extend at the knee, familiarizing themselves to the Biodex machine. After familiarizing, each individual was asked to complete a warm up consisting of 2 reps at approximately 50, 75, and 100% of their max effort allowing 30 seconds rest between each 2 rep set. Finally, "Run Test" was selected. The test consisted of 5 full effort concentric movements, through entire range of motion, for the anterior quadriceps and posterior hamstring muscles. Participants were reminded to put forth their full effort, generating the highest possible torque values for a strength assessment. This process was completed on dominant leg for each individual participant at a speed of 90°/second. Each participant's peak torque value out of the five trials was recorded for data analysis.

Push-Ups

A push-up test was administered in order to assess upper body muscle strength and endurance. Before completing the push-up test proper form and technique was reviewed with each participant. Push-ups would be counted only if during the eccentric portion of the exercise the elbows made a 90° angle. The participants back and legs were to remain straight and aligned throughout the test. Special considerations and testing procedures were explained. Push-ups were counted continuously until participant failure. There was no time limit to this test; participants were simply advised to do as many "quality push-ups as possible until failure." Any breaks or pauses in continuous motion were considered the end of the test. Participants were allowed when ready to begin the push-up test at their convenience. Acceptable push-ups were counted by two individuals who shared their totals at the conclusion of the test to confirm accuracy. Allow there were no discrepancies between counters; any disagreement in final count number would have resulted in a mean value being calculated.

Forestry Step Test

The Forestry step test was administered in order to determine approximate VO_2 max of the participants. In order to complete the test, a step box was set up at a 40cm height. Participants were fitted with heart rate monitors. A metronome was set to 80 beats per minute and turned on such that the participants could hear it well. The participants were advised to practice stepping with both feet forward up onto and then backward off of the step box to the metronome timing to become familiarized. After feeling comfortable with the step process participants sat down and rested for 2 minutes. At the end of the 2 minutes, their resting heart rates were recorded. Participants were asked to begin the test stepping up and back down as they had practiced, each time touching the step box with both feet before stepping back down. A stopwatch was started as the participants began moving. The Forestry Step Test lasts 5 full minutes. At the end of 5 minutes, participants were asked to sit immediately in order to track their heart rate recovery. At time point 5:15, 5:25, and 5:30 minutes a heart rate value was recorded. At the completion of collecting the final time point value heart rate monitors were removed from the participants and they were washed thoroughly for subsequent use.

Sit and Reach

After completing the Forestry Step Test, while the participants' muscles were still warm they were asked to complete a Sit and Reach test. The Sit and Reach test was administrated to assess flexibility in each of the participants. The participants were asked to remove their shoes and sit against a wall such that their lower back was touching and their hips were moved back toward the wall as much as possible. The Sit and Reach box was moved to allow for the bottom of each individual's feet to touch the vertical portion of the box while their legs remained fully extended. The participants were asked to bend at their hips reaching their out-stretched arms toward the box. A ruler fastened on top of the box allowed for their distance to be measured. Participants were instructed to bend and reach all while keeping their legs fully extended, no bending of the knee. At full reach length, they were asked to pause in order to measure the distance they had moved on the ruler, their values were measured and recorded in inches.

Computations & Analysis

Data from both pre and post tests were collected and recorded into Microsoft Excel. Paired T-tests were performed using pre and post test data from the Biodex, Push-Up to Failure, Forestry Step, and Sit and Reach tests in order to determine existence of statistically significant results. Using information from the Push-Up to Failure test, one repetition maximum (1-RM) bench press was estimated. Similarly using the Forestry Step test maximum oxygen consumption (VO_2 Max) was determined using heart rate recovery data. For each group of participants data were compared from pre and post-tests. An alpha level of 0.05 was chosen for this experiment. All statistical analyses were computed using Microsoft Excel 2010 software.

Results

Data were recorded for a group of College at Brockport ROTC cadets (n=10). The data were analyzed and compared for each test group. The TC 3-22.20 (MSI & MSII) and CrossFit (MSIII) group data were collected at the start of the four week period. After four weeks the cadets were tested again and post-test data were compared to that of the pre-test.

Figure 4: Knee Flexion Dominant Leg 90°/Sec (ft-lbs)

Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	48.26	57.18	8.92	16.92	0.196
CrossFit	56.68	58.06	1.38	2.40	0.607

Using Biodex System II Isokinetic Dynamometer lower body strength was measured through concentric knee flexion of the dominant leg at a velocity of 90°/sec. Five consecutive trials were performed by each participant. The peak torque value was recorded and utilized in data analysis.

Figure 5: Knee Extension Dominant Leg 90°/Sec (ft-lbs)					
Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	113.52	121.02	7.5	6.40	0.150
CrossFit	103.42	108.02	4.6	4.40	0.700

Biodex System II Isokinetic Dynamometer measured the peak torque produced by each participant during concentric knee extension of the dominant leg at a speed of 90°/sec. Like the knee flexion test, five consecutive trials were completed by each cadet. The data were recorded and analyzed. The average was taken for each set of group data.

Figure 6: Flexibility-Sit and Reach (in)					
Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	6.35	3.90	-2.45	-47.8	0.128
CrossFit	9.0	8.06	-0.94	-11.0	0.470

Flexibility was measured using a standard Sit and Reach test. This test was administered after participants had warmed up their muscles by completing the Forestry Step test. Each participant completed two consecutive trials and the average of the two was calculated.

Figure 7: Push-Ups to Failure					
Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	44.0	30.2	-13.8	-37.2	0.094
CrossFit	73.8	78.2	4.4	5.79	0.077

Each participant completed a Push-Up to Failure test both pre and post training. The data from each test was recorded and a group average was calculated for TC 3-22.20 and CrossFit testing groups.

Figure 8: Estimated 1-RM (lbs)					
Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	164.7	120.2	-44.5	-31.2	0.094
CrossFit	239.0	248.9	9.9	4.05	0.075

The Mayhew Formula[16], 1-RM = 0.014(PU*kg) + 29, in conjunction with push-up count and participant weight were used to calculated an estimated one repetition maximum (1-RM) bench press for each participant. The data from the Push-Up to Failure test above was input into the equation for each group.

Figure 9: Estimated VO_2 Max (ml/kg/min)					
Group	*Pre (mean)*	*Post (mean)*	*Difference*	*% Difference*	*P-Value*
TC 3-22.20	46.8	31.2	-15.6	-40.0	0.052
CrossFit	47.4	48.0	0.60	1.27	0.863

The Forestry Step test was utilized to estimate the VO_2 Max of the participants. After completing the Forestry Step Test, an average recovery heart rate value was taken using the specified time points from this test's protocol. This value was compared to charts designed for this test which yield a non-adjusted and age-adjusted VO_2 Max value based upon normative data.

Discussion

There was a noticeable increase in average strength of both the TC 3-22.20 group and the CrossFit groups' concentric flexion at the knee. The TC 3-22.20 group created a 16.92% increase in

average group strength between pre and post-tests, while the CrossFit group created a 2.40% increase in average group strength. The TC 3-22.20 test groups' knee flexion strength increases may be an adaptation produced by their training program. Based upon the sample training program shown above (Figure 3) one can theorize that exercises such as butt kicks, walking lunges, and suicide sprints effectively train the hamstring muscle group of the upper posterior leg specifically. The MSI's and MSII's started the four week trial period with an average strength of flexion that was below their counterparts'. Therefore, if starting at a lower level of initial strength, more neuromuscular junctions may have been created in the TC 3-22.20 group as a result of general training, but not simply because of the TC 3-22.20 training program. The CrossFit group performed squats and ran during their testing, but there were not the same hamstring targeting exercises which may explain a smaller increase in strength of 2.40% rather than 16.92% in the TC 3-22.20 test group. However, T-tests show P-values that indicate there were no statistically significant changes in either group.

Average leg extension strength was also increased in both groups. The TC 3-22.20 group increased average group strength, creating a 6.40% increase. The CrossFit group also elicited an increase in average group strength to the tune of 4.40% between pre-test to post-test values. Strength gains in each groups' average knee extension strength were similar. Coincidentally, both groups performed squats and performed runs regularly during their training. Both the TC 3-22.20 and the CrossFit group gained comparable concentric knee extension strength between pre and post testing. One may argue that this is due to the training programs having a similar format targeted toward the quadriceps muscles in the upper leg. Paired T-tests performed using Microsoft Excel resulted in no statistically significant changes in either group.

Flexibility measurements in each group was decreased (-47.8%) TC 3-22.20 and (-11.0%) CrossFit. The decrease in average group flexibility measurements for the TC 3-22.20 (6.35 inches to 3.90 inches) was profound. While the CrossFit group average flexibility decreased (9.0 inches to 8.06 inches). Flexibility decreases such as those shown in test group TC 3-22.20 are sizeable. In examining the training protocol, it is difficult to point out exercises or perhaps, a lack thereof that would elicit such a drastic decrease in just four weeks. Musculoskeletal damage, soreness, or minor injuries as a result of overtraining may explain some level of decrease in flexibility. T-tests performed, however resulted in no statistically significant changes in either group's data.

There was a group decrease in TC 3-22.20 average push-up count from 44.0 to 30.2. The percent difference in pre and post-test push-ups was 37.2% decrease. The CrossFit group showed an increase in group average push-up count from pre to post-test, 73.8 to 78.2. There was a 5.79% increase in average push-ups to failure for the CrossFit testing group. Decreases in push up count in the TC 3-22.20 test group may be an indicator of lack of motivation or overtraining of those muscles. In following the TC 3-22.20 training protocol, push-ups are emphasized greatly and adaptations should cause numbers to improve, rather than deteriorate. The CrossFit participants (MSIII's) training shows a similarly extensive emphasis placed on push-ups, resulting in an expected increase in push-ups to failure as a group between the pre and post-test. T-test showed there were no statistically significant changes. Although the P-value for the CrossFit group between pre and post-test, 0.077, was nearly significant

1-RM estimate of the TC 3-22.20 groups' data were noticeably lower in post-testing than in pre-testing. The average 1-RM for this group decreased from 164.7lbs to 120.2lbs as a result of a net decrease in push-ups to failure for this group. This decrease corresponds to a 31.2% decline in estimated 1-RM for the TC 3-22.20 test group. Unlike TC 3-22.20, the CrossFit test group shows a net increase in push-ups to failure, resulting in an increase in average group 1-RM from pre to post test (239.0lbs to 248.9lbs). This increase is indicative a of a 4.05% increase in estimated 1-RM as a result of training. There were no statistically significant changes indicated after performing a paired T-test. Although the CrossFit group P-value was 0.075 which is nearly significant statistically, as seen in the push-up to failure data.

The TC 3-22.20 group average VO_2 Max estimate between pre and post-test decreased from 46.8ml/kg/min to 31.2ml/kg/min, an overall decline of 40%. Given the TC 3-22.20 training program the MSI's and MSII's should have increased their cardiovascular endurance. Decreases in VO_2 Max estimates of the TC 3-22.20 group may be a result of dehydration. In order to compensate in a dehydrated state for low stroke volume (SV) the body will have to increase heart rate in order to maintain the same cardiac output (CO) it would in a hydrated state (CO = HR x SV). Because the equations for estimating VO_2 Max are heart rate (HR) dependent, this would directly impact estimates. Hydration was not controlled in this study therefore the participants' water intake was not mandated. The CrossFit test group average VO_2 Max estimate increased pre to post-test from 47.4ml/kg/min to 48ml/kg/min. The percent difference was calculated, 1.27% increase. This increase for the CrossFit test group is to be expected in a four week span of time. Paired T-tests performed resulted in a negative statistically significant change in the TC 3-22.20 group's VO_2 Max estimate. There was no statistically significant change in estimated VO_2 Max for the CrossFit group.

Conclusion

Military success is vital to a soldiers' livelihood and well-being. A soldier's success may have severe physical consequences including significant injury and even death.[1, 4, 6-10] In order for military personnel to be successful they must be in peak physical condition. Throughout history military fitness has been prioritized as a necessity which can enhance or severely limit a soldier's achievement. However in the past two decades it seems there has been a growing disparity in the physical training of elite level athletes and tactical athletes or soldiers.[1, 7, 8] with increased technology and resources' being offered to professional athletes it seems that military personnel are more than deserving of more modern training techniques.

The University of Pittsburgh with the Department of Defense have, in the past four years, compiled significant research pertaining to combat-related injury and unintentional injuries sustained by soldiers in the American Armed Forces. Using this information training protocols for military personnel have been updated and adapted to provide novel Physical Readiness Training to our military men and women.[6.-8.10] Training protocol TC 3-22.20 has been created in an effort to provide a program which can be implemented by any population of military personnel, including Special Operating Forces.[7,8] Similarly, Greg Glassman has created a training program advertised to be optimal for training all athletes, tactical included, for universal applications.[11,13,14] CrossFit has

become a popular training regimen for emergency service agencies nationwide such as police, fire, and emergency medical specialists. CrossFit is now becoming more common among military outfits preparing for strenuous physical testing or tours of duty. Challenging, effective training programs are vital to the success and well-being of military personnel as their lives can be dependent upon their physical training.

The College at Brockport, State University of New York's, ROTC program prepares college students to become Army Officers, leading American Army personnel after graduation. The ROTC program is currently employing two training programs, the TC 3-22.20 Physical Readiness PT for the MSI and MSII cadets, and CrossFit for the MSIII's. A comparative study of the two programs' effectiveness was completed over the course of a four week period of time. It was hypothesized that the CrossFit program would elicit more effective adaptations as a result of training for four weeks. Despite positive increases in lower and upper body strength, upper body muscle endurance, and estimated VO_2 Max; there is not enough evidence to fully conclude, based upon the results of this study, superior physical fitness improvement as a result of the CrossFit training program as opposed to the TC 3-22.20 protocol.

There is little known research available pertaining to this research topic. In order to provide a conclusion for the enhanced effectiveness of the TC 3-22.20 protocol or the CrossFit program there would need to be further research conducted. There is a plethora of standing evidence that suggests these two training programs are among the best in military training effectiveness and injury prevention. In the future more research will be necessary in order to provide more suitable support for either one of the two training modalities in ROTC cadets and commissioned soldiers with the American Armed Forces.

Limitations

One limitation of this study was the training or adaptation period. If there was more time available for study, the timeline would have been extended to eight weeks rather than four. An eight week timeline would have allowed for neuromuscular adaptations as well as hypertrophy of muscle fibers. Given the four week period between pre and post-testing in this particular study, any hypertrophy of muscle fibers would be negligible. Significant hypertrophy adaptations require a minimum of four to six weeks to elicit noticeable gains. As a result the changes in strength measurements would have been increasingly pronounced given more time to allow for hypertrophy. A four week timeline allows only for neuromuscular adaptation within skeletal muscle to be fully achieved. Neuromuscular adaptation alone accounts for a much smaller increase, if any, than when paired with hypertrophy.

Sample size presents another challenge for this study. There were ten total participants, five from each testing group. In order to create a feasible study on a short timeline, however, the sample size had to remain relatively small in relation to other similar studies. Consequently, statistically significant data were difficult to uncover. Had the sample size been larger, there is a much greater chance that this study may have produced more statistically significant findings in favor of one training program's effectiveness in comparison to the other.

Finally, lack of participant control and participant motivation to perform in this study may have caused some data to be inaccurate. Specifically, in the TC 3-22.20 test group the decreases in upper body strength, endurance, and VO_2 Max seem much lower than expected. This decline may be a combination of several factors rather than simply a result of the training program. Participants in this study were not given any structure outside of their training procedures. They were not given specific dietary guidelines, nor were they limited in their personal life decisions such as additional exercise or weekend alcohol consumption. The participants in this study were not given additional requirements or structure outside their training program and testing schedule. Consequently, the disparities that are presented in some of the data may suggest that these limitations caused unnecessary decreases in some of the post-testing data.

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Appendix A: Institutional Review Board Proposal Questions

1. Provide a Brief Description

A) Purpose & Objectives

The objectives of this research project are to perform a comparative analysis of the CrossFit physical fitness program and Army Physical Combat Readiness protocol TC 3-22.20 in Brockport ROTC military personnel. In order to remain in the ROTC, Officer Training Program, physical standards must be met by all participating cadets. As a result, maximizing physical training effectiveness becomes imperative for ROTC leadership and students.

As the physical standards are modified to become more stringent Brockport has introduced a new training technique to improve the level of fitness in the Brockport cadets. The new training program, based off the CrossFit model developed by Greg Glassman, is purported to have tremendous total body training results. As it is being implemented now, only the 3rd year students (MSIII's) are participating in CrossFit training (Glassman, G. 2007). With the permission of the Brockport ROTC Cadre I will complete physical testing in order to provide quantified data for the MSIII training program as compared to the traditional Physical Training regimen the 1st and 2nd year cadets, MSI's and MSII's respectively, complete three times a week. As the Cadre decide whether or not to continue this training protocol for their cadets in the future, additional data will be helpful in determining the effectiveness in this program.

Methods and Procedure

ROTC leadership will be asked permission for a sample of consensual cadets (10 total) to participate in a 4 week long physical training program study. Physical testing will be completed for each of the 10 individuals at the start of the four week period and again at the end during normal Physical Training (PT) scheduled time; 6:30am to 7:30am Monday, Wednesday, and Fridays. Testing will be completed during normally scheduled PT times on a one-on-one basis. Each cadet will be tested individually per confidentiality and thorough safety precautions

Both the experimental and the control group will be pre-tested prior to beginning the study and post-tested at the completion of this 4 week study using the Army Physical Fitness Test (APFT). All participants will complete an assessment of strength using a Biodex System 2 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, NY). The isokinetic instrument will measure peak torque created in the quadriceps and hamstrings throughout a full range of motion at a pre-set velocity of 90 degrees/second. In order to assess upper body strength a one rep max estimation will be determined using data derived from a submaximal push up to failure exercise test (Guenther. 2009). Flexibility will be measured using a modified Wall Sit and Reach test (Mackenzie, B. 2003). Cardiovascular endurance assessment is to be completed both prior to training and after the 4 week training period has ended using a Sharkey/Forestry step test for VO_2 estimation developed by the National Wildfire Coordinating Group in conjunction with USDA (NWCG. 2003). Data will be compared between the two groups APFT scores to assess the effectiveness of this training regimen on the Army Physical Fitness Standards. Additionally, the effectiveness of the training program will be assessed on an individual level to validate any change or improvement in personal strength, flexibility, and endurance.

Control Group Protocol
The control group of five MSI and MSII cadets will continue traditional ROTC physical training as scheduled Monday, Wednesday, and Friday mornings from 6:30-7:30. Their physical training program will remain consistent with the formulated military protocol TC 3-22.20 (Army Physical Readiness Training, 2010) employed at The College at Brockport.

Experimental Group Training Protocol
The experimental group, MSIII's, will continue CrossFit training as scheduled for the four week trial period. The MSIII's will maintain CrossFit training in place of the traditional Physical Readiness training protocol TC 3-22.20.

2. Number and Relevant Characteristics of Participants

Permission will be asked of The College at Brockport ROTC Leadership to allow a random sample of 10 consensual male Brockport ROTC cadets over the age of 18 to participate in this study. 5 MSI, MSII cadets will continue with the traditional PT, while 5 will perform CrossFit.

3. Description of how subjects will be selected for participation and description of remuneration to be received by subjects

Interested participants will be asked to participate for no monetary gain. ROTC cadets are required to complete physical training (PT) every Monday, Wednesday, and Friday each week. Cadets in the experimental group participate in the CrossFit training regimen as scheduled, rather than traditional PT.

4. Status and Qualification of Research Assistants

The PI, a senior biology major, will be the chief administrator of the testing and training procedures. PI has taken several courses in exercise physiology and is New York State Certified EMT (ID # 387210). PI has been instructed on safe practices and precautions of using equipment for exercise testing; Heart Rate Monitor, Sit and Reach Box, Biodex Machinery. Senior thesis advisor, Director of Athletic Training Education, Dr. Tim Henry will guide and direct procedures where necessary to ensure safety of all participants.

5. Source of Funding

PI will be the sole contributor and provider or any funding necessary to complete the study.

6. Expected Starting and Completion Dates

Data collection and testing are expected to begin April 2012 and come to completion May 2012.

7. Questionnaires, Testing Instruments, and Instructions to Subjects

N/A

8. Online Training Course Completion

See Transcript Attached

9. Specify steps to be taken to guard the confidentiality of participant's

Participant's data, performance records, will be kept locked in the research lab and will be destroyed following the completion of the research project and manuscript formation.

10. Attach an informed consent document that includes the basic elements of informed consent

Please See Attached

11. Documentation of permission

Please See Attached

12. Attach samples of interview or survey questions

N/A

13. Specify any specific populations

N/A

14. Psychological interventions

N/A

15. Treatments upon the body of the participants

See Attached Form 101

16. Possible injuries within study

See Attached Form 404

CITI Collaborative Institutional Training Initiative (CITI)

Humanities Responsible Conduct of Research Curriculum Completion Report
Printed on 2/17/2012

Learner: Richard LaFountain (username: rlafo1)
Institution: SUNY - College at Brockport
Contact Information Department: Health Center
Phone: (585) 395-5431
Email: rlafo1@brockport.edu

Humanities Responsible Conduct of Research: This course is for investigators, staff and students with an interest or focus in the **Humanities** research. This course contains text, embedded case studies AND quizzes.

Stage 1. RCR Passed on 02/17/12 (Ref # 7502234)

Elective Modules	Date Completed	
Introduction to the Responsible Conduct of Research	09/03/09	no quiz
Research Misconduct 4-1497	02/16/12	4/5 (80%)
Data Acquisition, Management, Sharing and Ownership 4-1525	02/16/12	5/5 (100%)
Publication Practices and Responsible Authorship 4-1533	02/16/12	5/5 (100%)
Peer Review 4-1534	02/16/12	5/5 (100%)
Mentor and Trainee Responsibilities 01234 1250	02/16/12	5/6 (83%)
Using Animal Subjects in Research 13301	02/16/12	6/8 (75%)
Conflicts of Interest and Commitment 4-1624	02/16/12	4/5 (80%)
Collaborative Research 4-1058	02/16/12	3/5 (60%)
Human Subjects 13566	02/16/12	9/11 (82%)
The CITI RCR Course Completion Page	02/17/12	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

Appendix C: Statement of Informed Consent

STATEMENT OF INFORMED CONSENT

The purpose of this research project is to examine the effects of a specific physical training program for use in ROTC cadets. CrossFit training completed by MSIII cadets will be compared to traditional ROTC Physical Training procedures. This research project is being conducted in order to complete the senior thesis capstone for the Honors Department at the College at Brockport, SUNY.

Research methodology was chosen over several other potentials due to the minimal risk involved for the participants. It is paramount that the ROTC cadets are not put in a position in which they could unintentionally injure themselves. As a result, the testing procedures chosen were among the most noninvasive known options. The strength assessments chosen, the push-up to failure and the Biodex System 2 pose negligible risks to the participant as opposed to a free-weight 1-Rep Max Bench Press or a Squat test for example. Similarly, in order to attain a Maximal Oxygen Consumption (VO_2 Max) measurement a simple five minute step test will induce minor risk as compared to a full test to exhaustion such as a Ellestad protocol (Adams, Beam; 2011).

This study will be helpful and informative as the training procedures are modified and analyzed based upon their effectiveness in ROTC cadets. Quantified data will allow Brockport ROTC Cadre to make informed decisions about efficient training practices in the coming semesters and academic years.

In order to participate in this study, your informed consent is required. You are being asked to make a decision whether or not to participate in the project. If you want to participate in the project, and agree with the statements below, please sign your name in the space provided at the end. You may change your mind at any time and leave the study without penalty, even after the study has begun.

I understand that:

1. My participation is voluntary and I have the right to refuse to answer any questions.
2. My confidentiality is protected. If any publication results from this research, I would not be identified by name.
3. Participating in exercise will always have the risk of possible injury and although unlikely, possible death. However, anticipated risks involved with this research such as muscle soreness, fatigue, minor musculoskeletal injuries (ie. strains, sprains) are no greater than risks associated with traditional ROTC physical training procedures.
4. Approximately 10 people will take part in this study. The results will be used for the completion of an Honors senior research thesis by the primary researcher.
5. Data will be kept in a locked filing cabinet by the investigator. Data and consent forms will be destroyed by shredding when the research has been accepted and approved.
6. The time commitment for this study will be kept the same as the time commitment for Physical Training (PT). There will be no additional request of my time outside of the scheduled PT times, between 6:00-7:30am, Monday, Wednesday, and Friday Mornings.

I am 18 years of age or older. I have read and understand the above statements. All my questions about my participation in this study have been answered to my satisfaction. I agree to participate in the study realizing I may withdraw without penalty at any time during the survey process.

If you have any questions you may contact:

Primary Researcher
Richard LaFountain
rlafo1@brockport.edu
585-313-3275

Faculty Advisor
Dr. Timothy Henry
Associate Professor, KSSPE
Director, Athletic Training Education
thenry@brockport.edu
585-395-5357

Signature_____ Date_____

Appendix D: Statement of Permission Agreement

STATEMENT OF PERMISSION AGREEMENT

I _____ have met with Rich LaFountain to discuss the methodology and procedures involved with his Honors Senior Research Thesis Project. Possible risks to the participants have been discussed during our meeting. I understand that all participants have the right to discontinue their involvement at any time during the research process.

I hereby give Rich LaFountain permission to move forward with his Institutional Review Board Application. I will allow 10 consensual cadets to participate in this research project. I understand that data collection is scheduled to begin April 2012 and end in May 2012.

With any questions, concerns, or grievances I will be sure to contact Rich LaFountain to address these issues.

Rich LaFountain
rlafo1@brockport.edu
(585) 313-3275

Signature: _____

Date: _____

Appendix E: Form 101

1. Form 101 - Research Utilizing Equipment
If the participant(s) in your proposed research will be in contact with any mechanical, electronic, electrical or other equipment which might subject him/her to the possibility of accidental harm or injury, please provide the information requested in items A-F below. The use of any such equipment must be approved by the IRB prior to use in any research.

A. Identify and describe in detail the equipment to be utilized. Use manufacturer's names and submit copies of manufacturer's literature on the equipment when available. Submission of schematics of electrical equipment will facilitate approval.

Biodex System 2 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, New York) – an instrument that can calculate force or torque generated using velocity of rotational movement. Dynamometers are used often to quantify strength due to relative ease of use for untrained individuals, their diverse applications, and the limited physical risk that they cause the testee. The Biodex Dynamometer is located in the College at Brockport Athletic Training Facility and is routinely utilized to train and test student-athletes at Brockport.

B. Identify and describe in detail how the participant will interact with the equipment.

The participant will be seated and fitted to the Biodex. Following a brief warm-up and familiarization period, the participant will be asked to flex and extend the knee joint as the Biodex instrument limits the rotational velocity to 90˚ per second while simultaneously calculating the force output generated by the participant. During flexion the posterior portion of the thigh muscles, the hamstrings, will contract. Adversely, when extending at the knee the anterior muscles of the thigh, the quadriceps, will contract.

C. Indicate the exact location of the equipment.

Tuttle South; Athletic Training Facility

D. Indicate the names and qualifications (with regard to the safe use of the equipment) for all individuals authorized to use the equipment for this proposal.

Dr. Timothy J. Henry, Associate Professor, KSSPE, Director; Athletic Training Education

E. Indicate in detail specific steps that will be taken to assure the proper operating and maintenance of the equipment.

Equipment will be operated only to the specific specifications listed in the operation manual. Dr. Henry will oversee the proper application of the Biodex Isokinetic Dynamometer to ensure equipment is utilized properly and safely.

4. **Form 404 - Subject at Risk**
If you believe that humans participating in this proposed research proposal MAY BE EXPOSED to the possibility of injury, including physiological, psychological, or social injury, please provide the information requested in items A-D below.

A. Identify and describe the possible risks, including psychological, physiological, or social injury to which participant(s) involved in the proposed research project may be exposed.

The physiological risks the participants may be exposed to are less than that which their physical training will induce. Participants have very slight risks involving minor muscle soreness or fatigue due to physical testing procedures. The participants' physiological risk will be further minimized as the PI will be trained and assisted throughout testing by an experienced Certified Athletic Trainer who has many years of experience operating the testing equipment. Additionally, participating in exercise will always have the risk of possible injury and although unlikely, possible death. Furthermore, the remaining testing protocols require only that the participants perform push-ups, stretching, and a brief 5 minute step test in order to assess the full spectrum of fitness requirements included in this study.

B. Explain why you believe the risks to the participants are so outweighed by the sum of the benefit to the participant and the importance of the knowledge to be gained as to warrant a decision to allow the participant to accept these risks. Discuss alternative ways of conducting the research and why the one chosen is superior.

This particular research methodology was chosen over several other potentials due to the minimal risk involved for the participants. It is paramount that the ROTC cadets are not put in a position in which they could unintentionally injure themselves. As a result, the testing procedures chosen were among the most noninvasive known options. The strength assessments chosen, the push-up to failure and the Biodex System 2 pose negligible risks to the participant as opposed to a free-weight 1-Rep Max Bench Press or a Squat test for example. Similarly, in order to attain a Maximal Oxygen Consumption (VO_2 Max) measurement a simple five minute step test will induce minor risk as compared to a full test to exhaustion such as a Ellestad protocol (Adams, Beam; 2011).

This study will allow for knowledge to be accrued that will be helpful and informative as the training procedures are modified and analyzed based upon their effectiveness in ROTC cadets. Quantified data will allow Brockport ROTC Cadre to make informed decisions about efficient training practices in the coming semesters and academic years.

C. Explain fully how the rights and welfare of the participants at risk will be protected (e.g. equipment closely monitored, medical exam given prior to procedures, psychological screening of prospective participants, etc.).

The rights and the welfare of the participants will be protected at all times throughout this study. All equipment will be closely monitored in each trial. Each participant will be tested on a one on one basis such as to insure safe practices throughout the entire testing process. All participants will be screened for any health risks prior to inclusion in this study by the ROTC Cadre. Cadets unable to attend Physical Training with their peers for health related reasons or restrictions will be excluded from this study by default.

D. Specify how legally informed consent will be obtained.

Legally informed consent will be obtained through a written description and an informed consent document. The participants will be well aware of their rights to discontinue their participation in this study at any time. They will be informed of the benefits and any possible risks that may be involved with participation of this specific research study prior to their inclusion in the study. All consensual participants will be asked to sign the Informed Consent document as a symbol of their legal consent to participation.

RECRUITMENT SCRIPT

The participants will be introduced and informed about this study according to the script below:

"My name is Rich LaFountain. I am a senior hoping to graduate in May. As part of the Honors Program Cap-Stone Thesis Project, I am conducting a comparative study using the MSIII Physical Training – CrossFit integration vs. Physical Training completed by MSI's and MSII's.

I am going to acquire basic strength, endurance, and flexibility data using a battery of four quick and easy tests. I need five willing MSIII participants as well as five MSI or MSII participants. The time requirement is congruent with your PT times Mondays, Wednesdays, and Fridays. I need only to collect pre-test data once in the beginning of April and again four weeks later. I will quantify this data in order to help determine the effectiveness of these two programs. Finally I will present my findings to the ROTC Cadre in an effort to help make informed decisions about training protocols in the future.

Thank you so much for your time. Please feel free to ask me any questions or bring up any possible concerns you may have in regards to participation. Thanks again."