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Critical Velocity is Associated with Combat Specific Performance Measures in a Special Forces Unit

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CRITICAL VELOCITY IS ASSOCIATED WITH COMBAT SPECIFIC PERFORMANCE MEASURES IN A SPECIAL FORCES UNIT

by
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ABSTRACT

Over recent years, military research has focused on ways of being able to predict operational success and readiness through the development of simulated operational tasks measuring the physical limits of the soldier. Therefore, to properly prepare the tactical athlete for the demands and rigor of combat, accurate assessment of baseline physical abilities and limitations are necessary. Currently, western armies use a basic physical fitness test, which has been heavily argued to have no bearing on operational readiness, thus they are in the process of transitioning to a more specific combat readiness test. However, specific assessments to predict operational success/readiness are inefficient or lacking. A single test that requires minimal time, but provides simultaneous assessment of the necessary physical characteristics (i.e. aerobic and anaerobic capacities) may provide a unique opportunity to enhance soldier performance assessment. The 3-min all-out run, is a relatively new test that has been recently validated. It provides two performance estimates, critical velocity (CV) and anaerobic distance capacity (ADC). CV provides a measure of the individual's aerobic capacity, while the ADC is an indicator of anaerobic capacity. The purpose of this study, therefore, is to examine the relationship between CV and ADC from the 3-min all-out run and combat specific tasks (2.5-km run, 50-m casualty carry, and repeated sprints with rush shooting) in an elite special force unit.

Eighteen male soldiers (age: 19.9 ± 0.8 years; height: 177.6 ± 6.6 cm; body mass: 74.1 ± 5.8 kg; BMI: 23.52 ± 1.63) from an elite combat special force unit of the Israel Defense Forces (IDF) volunteered to complete a 3-min all-out run, while wearing a global positioning system (GPS) unit, and a battery of operational CST (2.5-km run, 50-m casualty carry and 30-m repeated sprints with "rush" shooting (RPTDS)). Estimates of CV and ADC from the 3-min all-

out run were determined from the downloaded GPS data with CV calculated as the average velocity of the final 30 s of the run and ADC as the velocity-time integral above CV.

CV exhibited significant negative correlations with the 2.5-km run time ($r = -0.62$, $p < 0.01$), and RPTDS time ($r = -0.71 p < 0.01$). However, CV ($r = -0.31$) or ADC ($r = 0.16$) did not show any correlation with the 50-m casualty carry run. In addition, CV was positively correlated with the average velocity during the 2.5- km run ($r = 0.64$, $p < 0.01$). Stepwise regression identified CV as the most significant performance measure associated with the 2.5-km run time, and BMI and CV measures as significant predictors of RPTDS time ($R^2 = 0.67$, $p < 0.05$).

Our main findings indicate that CV was highly related to performance during CST, including the 2.5-km run and RPTDS, but not the 50-m casualty carry. Using the 3-min all-out run as a testing measurement offers a more efficient and simpler way in assessing both aerobic and anaerobic capabilities (CV and ADC) with-in a relatively large sample. In this regard, this method of testing may be conducive to a military type environment whether for selection purposes, to predict combat readiness, to prescribe a training program or just a need analysis for the company commander

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CHAPTER I: INTRODUCTION

The requirements of a tactical athlete to successfully complete combat specific tasks have been suggested to include high levels of both aerobic and anaerobic capacity, speed, strength, power, and a high level of cognitive and reactive awareness (Nindl et al., 2002; Kraemer et al., 2004; Harman et al., 2008; Harman et al., 2008; Sporis et al., 2012; Heinrich et al., 2012). The physical requirements for these operational tasks can be focused on the approach to the battlefield (e.g., marching or running with or without heavy loads across various terrains) and on combat specificity (e.g., repeated sprints from area of cover to cover, dragging or carrying wounded to safety, crawling, lifting, pulling, climbing, jumping and lunging (Bacthelor et al, 2008; Hendrickson et al., 2010; Heinrich et al., 2012; Spiering et al., 2012; Blount et al., 2013; Hoffman et al., 2014). In military operations, loss of physical capacity may decrease survivability for the combat operative (Thorlund et al., 2010). The tactical athlete, therefore, is expected to possess specific physical and cognitive skills in order to successfully adapt to the many demands and unexpected scenarios that will be faced on the battlefield.

Tactical engagement in the modern battlefield, especially within the close quarters and complex infrastructure of urban terrain, requires a high level of physical fitness and alertness (Blount et al., 2013). Evaluating the soldier's physical capability to perform and sustain such activity would appear necessary to properly prepare and select appropriate personnel. Recently, a number of studies have focused on developing valid and reliable military performance assessment measures (Heinrich et al., 2012; Spiering et al., 2012). Specifically, research has focused on predicting operational success and readiness by developing simulated operational tests that measure the physical limits of the soldier. As such, some studies have examined the relationships between physical fitness tests and actual performance on the battlefield (Nindl et al., 2002; Harman et al., 2008; Hendrickson et al., 2010; Heinrich et al., 2012; Blount et al., 2013), while others have analyzed the effectiveness of the Army Physical Fitness Test (APFT) compared to combat specific tasks (Batchelor et al., 2008; Cuddy et al., 2011; Heinrich et al., 2012; Spiering et al., 2012). In light of this, the US Army is in the process of evaluating a new soldier readiness assessment called the Army Combat Readiness Test (ACRT), which will focus more on combat specific tasks (running speed, victim rescue, load carrying and lifting, mobility, agility, balance etc.) (Spiering et al., 2012). However, to the best of our knowledge there are no predictive models for combat readiness that have been established.

Most western militaries, including the Israel Defense Forces (IDF) and American military utilize standard physical fitness tests such as the number of push-ups, number of sit-ups, body mass index and the time to complete a distance run to assess soldier fitness (Knapik et al., 1990; Knapik et al., 2005; Harman et al., 2008; Knapik et al., 2009; Cuddy et al., 2011; Blount et al., 2013). These physical assessments provide a measure of the health and fitness of the soldier, but they have not been validated for predicting operational success. Current physical assessments employed by most western militaries however, fail to evaluate the totality of physical demands and stressors, which together are vital for success in the combat environment. For example, high intensity activities such as sprinting across wide streets, climbing stairwells, carrying fallen comrades, wall climbs, engaging in 3-5 second “rush” sprinting are anaerobic demands that have been observed in both rural and urban environments (Heinrich et al., 2012; Blount et al., 2013) but are not assessed in any of the basic military assessments.

Within a military environment, one of the limitations often encountered is time. Adding additional physical performance measures to provide a more thorough physiological assessment of a soldier's combat readiness may be logistically difficult. However, a single test that requires minimal time, but provides simultaneous assessment of both aerobic power and anaerobic capacity may provide a unique opportunity to enhance soldier performance assessment. The 3-min all-out run, is a relatively new test that has been recently validated (Pettitt et al., 2012). It provides two performance estimates, critical velocity (CV) and anaerobic distance capacity (ADC). CV provides a measure of the individual's aerobic capacity, while the ADC is an indicator of anaerobic capacity (ADC).

The 3-min all out running test assessing CV is similar to the critical power test which uses a cycle ergometer to estimate the maximal theoretical power output (or velocity) at which a person can cycle for an extended period of time without inducing fatigue (Hill et al., 1999; Bull et al., 2008; Jones et al., 2010; Fukuda et al., 2012). The critical power concept was first established in 1965 by Monod and Scherrer, who defined the critical power of muscle (or muscle groups) as the "maximum rate power that can be maintained for a sustained time without fatigue." Furthermore, Jones et al. (2010), suggested that the CV represents the highest rate of oxidative metabolism that can be sustained without relying on energy turnover from substrate level phosphorylation, like PCr hydrolysis and anaerobic glycolysis. In previous research, CV has been associated with VO2 max, maximal lactate steady state (MLSS), distance running, and proposed as a basis to develop endurance training protocols, making it a strong predictor of aerobic performance (Denadai et al., 2005; Bull et al., 2008; Jones et al., 2010; Kendall et al., 2011; Fukuda et al., 2012; Clarke et al., 2013; Clarke et al., 2014).

The ADC has been defined as the distance or total work that can be completed using stored energy sources without oxygen or before the accumulation of fatiguing metabolites (Jones et al., 2008; Fukuda et al., 2012). Previous studies have demonstrated that the ADC can be increased via power or sprint training, (Jenkins et al., 1993; Jones et al., 2010), while both CV and ADC have been shown to increase with intermittent or continuous endurance exercise (Jenkins et al., 1993; Jones et al., 2010; Clarke et al., 2013; Clarke et al., 2014). Thus, the CV test may be used to identify both aerobic and anaerobic capacity.

In further support of the utility of the CP concept in a military setting, Fukuda et al (2012) identified the CV test as an alternative method of time trial testing and an improvement upon the two-mile run commonly utilized in the APFT. Using CV and ADC may provide a more accurate view of the necessary physiological requirements that pertain to the specific needs of combat performance. Physiological profiles developed from individual CV and ADC values may be useful in the development of a needs analyses for tactical athletes and the separation of large heterogeneous groups of soldiers into smaller specialized training program groups.

Overall, the 3-min all-out run test measuring CV and ADC may provide an efficient assessment of physical fitness, allow for the identification of exercise prescription needs, and potentially the prediction of performance during high-intensity exercise (Jones et al., 2010). The purpose of this investigation, therefore, is to examine the relationship between CV and ADC from the 3-min all-out run and combat specific tasks (2.5-km run, 50-m casualty carry, and repeated sprints with rush shooting) in an elite special force unit.

Purpose

1. To examine the relationship between the 3-min all-out run (CV and ADC) and combat specific tasks (2.5-km run, 50-m casualty carry, repeated sprints with rush shooting) in an elite special force unit.

Research Questions

1. Does CV from the 3-min all-out run test correlate with combat specific tasks (2.5-km run, 50-m casualty carry, and repeated sprints with rush shootings)?
2. Does ADC from the 3-min all-out run test correlate with combat specific tasks (2.5-km run, 50-m casualty carry, and repeated sprints with rush shootings)?

Hypotheses

1. CV will correlate with the 2.5-km run and repeated sprints
2. ADC will correlate with repeated sprints and 50-m casualty carry

Operational Definitions

1. Critical Velocity (CV) – The maximal velocity that an individual may theoretically maintain for an extended period of time with-out fatiguing. This will be determined from GPS data upon completion of the 3-min all-out run.
2. Anaerobic Distance Capacity (ADC) – The maximal distance an individual may theoretically cover using limited anaerobic storage capacity before the accumulation of fatiguing metabolites. This will be determined from GPS data upon completion of the 3-min all-out run.

3. Combat Specific Tasks (CST) – The simulated combat tasks that are being assessed: 2.5-km run, 50-m casualty carry and repeated sprints with “rush” shooting.

Abbreviations

ADC, W’ - Anaerobic Distance Capacity

AVG V 2.5-km – Average Velocity of 2.5-km run

BMI – Body Mass Index

CC – Casualty Carry

CST – Combat Specific Tasks

CV – Critical Velocity

GPS – Global Positioning System

RPTDS – Repeated Sprints with “Rush” Shooting

VO_{2max} – Maximal Oxygen Consumption

Delimitations

Eighteen Special Forces soldiers from the IDF volunteered for this study. All participants completed a written informed consent upon explanation of procedures, risks and benefits. The Helsinki committee of the IDF Medical Corp approved this research study. To be included in the study all participants had to be free of injury, up to date with the units training regimen and a completion of basic training. Participants maintained their normal diet and training schedule while enrolled in the study.

Assumptions

Theoretical Assumptions

1. Participants gave maximal effort and did not pace on any of the testing measures.
2. Participants gave their informed consent and were cleared medically for participation.
3. Combat specific tasks will correlate with CV and ADC measurements from the 3-min all-out run.

Statistical Assumptions

1. The dependent variables were normally distributed.
2. There needs to be a linear relationship between the dependent variables
3. There should be no significant outliers

Limitations

1. When dealing within a military setting, the possibility of any escalation that might occur or a change in their training that might halt the study.
2. Being a field study, the many unexpected issues that may occur that may not be fixable due to the limited amount of time with the unit.
3. The possibility of the soldiers not grasping the concept of an “all-out” test and adopting pacing strategies during testing protocols.
4. Limited numbers of volunteers (n = 18) with the concern of participant withdrawal.

CHAPTER II: LITERATURE REVIEW

There are many factors that play into the physiological demands (increase of external load, sleep deprivation, low caloric intake, long demanding marches, hypo- and hyperthermic conditions, etc.) which necessitates an understanding by higher command in order to properly assess and prepare soldiers to become as operational ready as possible. In order to advance forward in preparing these elite operators to become combat ready, understanding the reasons for why these warriors might encounter a decrement in operational performance is of vital importance. Therefore, the purpose of this literature review is to introduce the physical and physiological demands that may be required of the tactical athlete, along with how these operators and future tactical athletes might be assessed or evaluated.

<u>Physiological Demands of the Tactical Athlete:</u>

Knapik, Daniels, Murphy, Fitzgerald, Drews and Vogel, 1989

Physiological Factors in Infantry Operations

The purpose of this study was to investigate the role of physiological factors related to physical fitness in infantry operations. Thirty-four male infantry soldiers form four intact rifle squads participated in this study to see the effects of a five day combat simulated field exercises on the various physiological components that were measured pre and post. These soldiers were studied before, during, and after a five day simulated combat exercise. The five day simulated field tests were interposed between the pre and post testing. Three days prior to the study, the subjects participated in pre-testing where direct measures of body composition and maximal oxygen uptake were obtained. The post-testing was conducted immediately following the exercise simulation. The Army Physical Fitness Test (APFT) was also conducted pre and post testing, along with a rifle-shooting test. The rifle-shooting test involved shooting down pop-up targets as they appeared. Due to time limitation during the post testing, half of the soldiers completed measurements of upper body Wingates and knee-extension strength in the Thorstensson test, while other half of the subjects were tested on lower body Wingates and the elbow-flexion strength in the Thorstensson test. During the five day simulated field exercises, the soldiers were permitted to sleep for four hours each night and it was required of the subjects to perform both offensive and defensive maneuvers in a heavy woodland terrain with thick underbrush. Soldiers carried all necessary combat gear and supplies for the five consecutive days; however every 24 hours field rations (food) and ammunition (blanks) were resupplied at a predetermined location. Overall each solider carried approximately a total between 34-52 kg with one individual (communication operator) in each of the four squads carrying an extra 9 kg due to the radio. Some examples of the simulated field exercises included: raid and react, establish a rally point, react to mortar fire and evacuate, establish a patrol base, reconnaissance of specific areas, defend two hills while reacting to enemy fire, evacuate wounded, link up with other groups, secure and hold landing strip, react to enemy fire, supply and move to resupply point.

There was a significant decrement between pre to post testing during the APFT with decreases in both total push-ups and sit-ups (-9.4% and -7.8%, $P < 0.01$) and an increase in the 2-mile run time (-8.3%, $P < 0.01$). One of the major findings in this investigation was the decrement in upper body anaerobic capacity (Thorstensson and Wingate tests) and strength (push-ups and sit-ups) following the five day simulated combat field exercises. In regards to these reductions, it was also reported that the evaluators noticed some difficulty with the soldiers carrying the specific amount of loads (causality carries, communications operator, packs) and even cases of back problems being developed.

Another major finding during this investigation was the relationship between the individual performance scores and the physiological measurements. Pearson product moment correlations were run between all measurements, and only the rife-shootings and the five upper-body anaerobic and muscle strength measures were significantly correlated. There was a high level of aerobic fitness that was seen with the subjects compared to previous samples. However, during this study the simulated combat missions did not require a significant stimulation of the aerobic system over the five days.

Overall, this study suggests that upper body anaerobic exercise capacity and strength is vital for success with infantry men during specific combat operations.

Hoffman, 1997

The Relationship between Aerobic Fitness and Recovery from High-Intensity Exercise in Infantry Soldiers

The objective of this study was to examine the relationship between aerobic fitness (determined from a military field test) on recovery rates from anaerobic exercises (repeated sprint performance) in infantry soldiers. One hundred ninety-seven infantry soldiers (age 19.4 ±0.8 years) participated in this study. All soldiers were post basic training and were in either advanced infantry training or already operational. All soldiers performed both an aerobic fitness test (2 km run for maximal effort) and a repeated sprint test (140-m line drill) to assess anaerobic power and fitness.

The results of this study once again clarified that aerobic fitness appears to have an important role in the recovery process during repeated bouts of anaerobic exercise. However, this should not be mistaken for a constant aerobic fitness paradigm. In contrast to other studies, this investigation suggests that the relationship between aerobic fitness and recovery from high-intensity exercise may be limited after achievement of a basic level of aerobic fitness. The observed benefits with aerobic training is the enhancement of recovery between bouts of high-intensity exercise, which holds implications for combat specificity. Although upper body strength and anaerobic capacity are the primary factors in infantry operations (Knapik et al., 1989), aerobic training may serve as an important function in the physical development of the infantry soldier, solely in the importance of reducing fatigue rates and enhancing recovery during specific operations.

Nindl, Leone, Tharion, Johnson, Castellani, Patton and Montain, 2002

Physical Performance Responses During 72-h of Military Operational Stress.

The purpose of this investigation was to determine the impact of prolonged work, underfeeding, and sleep deprivation through sustained simulated operations (SUSOPS) on physical and occupational related performance during military operational stress. Fourteen healthy male subjects agreed to participate in this study upon being briefed on study procedures. The study utilized five different military specific measurements to provide an understanding of how these sustained operations might impact combat relevant tasks. Two 96-hour testing blocks were conducted, where the first week was used as a control week and to overcome any familiarizations of the testing. Physical performance tests consisted of: body comp (DEXA and skin folds), ballistic power tests (30 reps x 30% load bench throws and 30 reps x 30% load squat jumps), repetitive box lift (RBL) for 10 min (lift a 20.5 kg box as many times as possible onto 1.3 m platform), obstacle course (soldier mobility assessed via a six-station simulated military combat specific), grenade throw (threw dummy grenade at a target 35 m away, 5 separate throws), marksmanship (simulator with a mix of moving and stationary targets), wall building (assessing a prolonged repetitive physical task), and a profile of mood states (POMS) to assess subject mood states. These physical tests were performed on the morning of days 1 (D1), 3 (D3), and 4 (D4) of each test block. The control week did not include the sustained operations and food/sleep was not controlled, but only the experimental tests. The following week, it was a full go for the SUSOPS and food was limited to one meal and an additional small meal per day (total 2800-2900 kcal) along with restrictions on sleep to two 1-hour sleep periods per day. On each test day (D1, D3, D4) body mass was initially measured and a small meal was consumed. One hour later, subjects completed the POMS and began the wall-building test followed by the grenade throw and marksmanship testing. At exactly 0900 h, approximately 15 min of stretching and aerobic exercise were performed. Subjects were tested on the obstacle course and this occurred for two trials with a 15-minute rest period in between. Lastly, the participants were then divided into two groups where one group performed the RBL and the other the ballistic tests. Upon a 20-min rest period, the two groups switched stations. All physical tests were followed by the continuous field training tasks that consisted daily of the performance of military relevant tasks, which included: basic patrolling, combat drills, road marches, land navigation, a litter obstacle course, and a confidence course. It was hypothesized that several days of prolonged work, sleep deprivation, and limited food intake would reduce mean power during repetitive ballistic performance, lower maximal work productivity during physically exhausting work, and compromise military skill tasks and performance during self-paced work.

Overall, SUSOPS resulted in decreased ($p \leq 0.05$) vigor and increased ($p \leq 0.05$) tension, depression, anger, fatigue, and confusion. Body mass (BM), total soft-tissue lean and fat mass, percent body fat and soft tissue lean mass and fat mass from both arms and trunks declined as expected during the SUSOPS (BM being 2.1 and 2.5 kg lower on D3 and D4; total soft-tissue lean and fat mass declined ($p \leq 0.05$) by 1.5 kg and 1.2 kg; percent body fat decreased ($p \leq 0.05$) from 18.5 ± 5% to 17.7 ± 6%; soft-tissue lean mass in both arms and trunk declined ($p \leq 0.05$) by 4-5%; and fat mass declined ($p \leq 0.05$) 13% and 9%). Power of the lower body was mainly affected during the SUSOPS. A decline in both mean power and total work of the squat jump were seen upon D4 ($P \leq 0.05$). Interestingly, the number of boxes lifted decreased from 199.5 ± 12.5 on SUSOPS D1 to 182.8 ± 12.7 on SUSOPS D3, with a slight recovery on D4 (189.6 ± 12.7), which resulted in 8.5% less work completed on SUSOPS D3 (D1: 5289.3 ± 332 J vs. D3: 4848 ± 325 J). Wall building performances on D3 (6.0 ± 0.4 walls) and D4 (6.2 ± 0.4 walls) were ~25% lower ($P \leq 0.05$) than SUSOPS D1 (8.0 ± 0.4 walls).

These findings suggest that short-term (≤ 3 days) military operational stress adversely affect selected aspects of physical performance and demonstrate that three out of the four physically demanding performance tests were negatively affected at some point during SUSOPS. This was seen with decrements in lower body ballistic anaerobic performance, transient losses in the obstacle course, the RBL and lastly the wall-building task. This was as expected due to the over-utilized muscle groups and high levels of persistence without the adequate recovery.

However, these warriors were able to maintain their occupational skill tasks (soldier mobility on the obstacle course, grenade throw, marksmanship), which may be most crucial for survivability and mission success.

Riccardi, Deuster and Talbot, 2008

Metabolic Demands of Body Armor on Physical Performance in Simulated Conditions

The purpose of this study was to investigate the metabolic demands of body armor on physical performance during simulated operational conditions by examining physical work, energy cost, and physiological fatigue. A total of 34 military personnel (17 men and 17 women) agreed to participate. This study, used a within subject repeated measures design to undergo two experimental conditions: with body armor (BA+) and without BA (BA-) separated by a minimum of five days. On the no body armor day, subjects wore T-shirt, exercise shorts, socks, and jogging shows; while on the other day subjects wore body armor and an enhanced small arms protective insert plates (10 kg total) with a tactical Under Armour t-shirt. Subjects were tasked with walking 30-minute on a treadmill and completing various physical performance battery tests during each of the two sessions. During the treadmill test, subjects walked at a slow pace (2.3 mph for women, 2.4 mph for men) at a 5% incline for 10 minutes. The next 10 minutes, subjects walk increased to a moderate pace (3.6 mph for women and 3.8 mph for men) at a 10% incline. Upon completion of the 10 minutes, a cool down began for five minutes at a slow pace of 2.5 mph at 2% incline. $\dot{V}O_2$ values were obtained by averaging the last two minutes of each of the two 10-minute sessions. Hear rate, respiratory exchange ratio, respiratory rate, and rating of perceived exertion was all recorded as well. The physical performance tests consisted of three tasks: hand grip strength (hand dynamometer), stair stepping (stepped up and down as fast as possible within 1-minute), pull-ups (men- as many as possible) or hang time (women-as long as possible) using a pull-up bar. Lastly, blood lactate was also analyzed before and after completing treadmill test and subsequent to completing the physical performance battery.

All 34 subjects were able to complete the treadmill test at the slow pace whether wearing or not wearing the BA. However, six subjects (three men and three women) without BA- and 14 subjects (seven men and seven women) with BA+ were unable to complete the treadmill testing at moderate pace due to volitional fatigue, achieving $\dot{V}O_2max$ and/or limiting dyspnea. Subjects in the BA+ compared to the BA- had significantly higher $\dot{V}O_2$, HR, RR, and RPE in both slow and moderate paces. In regards to the blood lactate levels, subjects who walked at a moderate pace with BA+ showed a mean level of 6.7 ± 2.6 mmol/L, well above the 4.0-mmol/L threshold. Overall, 79% of the 34 subjects had lactate levels well above the 4.0 mmol/L threshold upon completing of the moderate pace treadmill testing with BA+. These levels may suggest the decrement in physical performance that was noticed. Upper body strength and lower body strength and endurance were significantly compromised when wearing BA+. Men performed 61% fewer pull-ups (3.6 ± 3.0 compared to 9.1 ± 5.8 BA-) and women's hang time was decreased by 63% (7.0 ± 9.5sec compared to 19.1 ± 15.4 BA-) when BA+ was added.

Therefore, wearing BA+ imposes a great metabolic cost and is seen to significantly impact a series of simulated physical conditions. This investigation suggests that the addition of BA with only a 15.7% increase has a significant impact on human physiology and performance.

Harman, Gutekunst, Frykman, Sharp, Nindl, Alemany and Mello, 2008

Prediction of Simulated Battlefield Physical Performance from Field-Expedient Tests

The purpose of this study was to determine if the specific field expedient tests used might be able to predict simulated physically demanding battlefield performance. Thirty-two civilian subjects were recruited for this research study. These 32 subjects had physical activity levels anywhere between sedentary and active, which is the typical of the population recruited for the army. All 32 subjects gave their informed consent upon passing the required physical examination to ensure all were fit for "duty". During the first eight weeks the investigators were preparing the subjects using military training methods to establish a baseline of military physical fitness, similar to what might be seen in basic training. Upon completing of the 8-week baseline training the research study began. The participants were tested over two weeks with focus on simple anthropometry (height and body mass), field-expedient physical fitness tests, and a simulated battlefield physical performance test. The field-expedient physical fitness test (FEPFT) included: the US APFT (as many push-ups as possible in two minutes, as many sit-ups in two minutes, and a 3.2 km run) and jumping tests (standing vertical jump and standing horizontal jump). The simulated battlefield physical performance consisted of: wearing full army combat dress attire (combat boots, Kevlar helmet, military armored vest with protective ceramic plates, a fighting vest with dummy ammunition, and carried a dummy M-16 rifle for total of approximately 18 kg), timed 400 m run; timed obstacle course (in order: 1. leap over 61 cm hurdles, 2. run in a zigzag around nine cones, 3. crawl under a rectangular barrier 0.6 m high 0.9 m wide and 3.7 m long, 4. shimmy 3.7 m along a 6-cm diameter horizontal pipe, 5. climb over a 1.4 m high sheer wooden wall, 6. sprint 29 m, 7. climb onto a 1.55 m higher sheer-faced platform, 8. and run up two flights of stairs); timed 30 m rushes (started in prone position and on command the subject got up sprinted 30 m and laid back down for a five second pause for a total of five rushes); simulated casualty rescue (50 m shuttle to an 80 kg survivor manikin and drag back 50 m to start). Within two week testing period Harman and colleague's (2008) used a Pearson product moment correlation (r) to notice any correlation between anthropometric measures, FEPFT and simulated battlefield physical performance test. Harman and colleague's (2008) also used a multiple linear regression to possibly predict any simulated battlefield physical performance from scores from the anthropometric measures and the FEPFT.

Harman and colleagues (2008) were able to notice correlations of body mass and sit up repetitions with body height especially when body height increased ($P < 0.05$). Increased body mass actually showed a trend towards a negative correlation with all physical fitness performance measures. A positive and significant correlation was also seen between horizontal jumps and the 3.2-km running ability. There were strong positive correlations within the simulated battlefield physical performance tests. The overall performances of both the 30-m rush and 400-m run tests correlated most significantly ($r = 0.87$, $p < 0.01$) with each other and all other tests within the simulated battlefield physical performance tests (casualty rescue and obstacle course), while casualty rescue and obstacle course tests were the least significant to associate with each other. When looking at overall correlations between all tests (anthropometric, FEPFT and the simulated battlefield physical performance tests) body mass showed strong correlations, especially with heavier body weight and faster times on the casualty rescue test. There were also strong and significant correlations ($p < 0.05$, $p < 0.01$) with greater vertical jump, greater horizontal jumps, greater number of push-ups, faster 3.2-km run times and faster times on the 400-m run, 30-m rush and obstacle course.

The data suggests that all four tests from the simulated military performance tests were well predicted when associating them with the anthropometric measures and the FEPFT, with r-values ranging from 0.77 to 0.82. With all the linear equations that were used, the vertical and horizontal jumps were the most useful variables for these predictions. Lower body power, which is a reflection of the vertical jump, is a significant relevant parameter of the kinds of high intensity and short duration activities that are simulated on the battlefield. The 3.2-km run was also a significant variable to predict performance in the simulated military battlefield performance tests. The 3.2-km run was also a relevant parameter for specific military tasks due to its endurance requirement that cannot be reproduced with the jumps. Overall, these two fitness parameters were determined to be the most significant tests to predict operational performances, as noticed when these two performances improved so did all the simulated military performances tests (30-m rushes, 400-m run, obstacle course and trends for the casualty rescue).

DeMaio, Onate, Swain, Morrison, Ringleb and Naiak, 2009

Physical Performance Decrements in Military Personnel Wearing Personal Protective Equipment (PPE)

The purpose of this study was to investigate the effects of personal protective equipment (PPE) on physical performance by cardiovascular, balance, strength and functional field tests. Nineteen male and 2 female (n = 21) U.S military volunteers from various commands on active duty who have much experience wearing PPE participated in this investigation. The PPE consisted of wearing a vest with chest and back ceramic plates and a helmet with an average weight of 9.8kg ± 0.9kg. All subjects completed a battery of physical performance tests with and without PPE. These physical battery tests consisted of: Aerobic capacity-VO2 max (a specific treadmill test of fast walking up steep grades), upper extremity climbing strength using a BYE primus RS dynamometer (measuring work output over a 30 s maximal effort with analysis of joules and repetitions), balance was assessed in four different postural conditions immediately before and after treadmill testing (standing on force plate- examining motion changes in anterior-posterior and medial-lateral center of pressure). Lastly, functional field-tests assessing anaerobic running (300 yard shuttle run), agility (box agility), and upper extremity power (rope pull and dummy drag). Along with the PPE, subjects also wore military issued battle dress uniforms (military boots and socks). The combat operators were tested on two different days with and without PPE and had a minimum of three days in between testing sessions.

During the treadmill test, times were significantly reduced by PPE from 16.4 ± 1.6 min to 14.4 ± 1.5 min ($p < 0.001$). A significant decrease in aerobic capacity from 48.3 ± 5.7 $ml \cdot min^{-1} \cdot kg^{-1}$ to 42.9 ± 4.9 $ml \cdot min^{-1} \cdot kg^{-1}$ ($p < 0.001$) was also noticed due to the weight of PPE. On the upper extremity climb analysis the negative effects were seen with PPE ($p = .001$). Subjects without PPE were able to complete five more climbing repetitions compared to when wearing PPE (No PPE = 51.3 reps ± 11.2 vs. PPE = 46.38 reps ± 11.1). During the field tests, a significant difference between PPE and control was noticed for the shuttle run ($p < 0.001$), but no significant differences were observed for the box agility ($p = 0.28$) or rope pull and dummy drag test ($p = 0.42$).

Overall, this investigation similar to previous ones was able to support the finding that PPE was responsible for decrements in aerobic capacity, upper extremity functional strength and functional field test performance. This once again shows the increase in the metabolic demands faced by combat operators.

Blount, Ringleb, Told, Bailey and Onate, 2013:

Incorporation of Physical Fitness in a Tactical Infantry Simulation

The purpose of this study was to investigate the differences of rush velocities through different operational simulations to possibly predict survivability. This study focused on the need for optimal physical fitness in order to increase survivability within these rush scenarios. Thirty one military personnel were involved in this investigation. This study was split into three categories of data collection: experimental data collection, spreadsheet model predicting results and the final results using an agent-based simulation.

During the experimental data collection, physical fitness data was collected on two separate days for each of the 31 participants. The goal of this investigation was to simulate modern battlefield conditions and what might be expected of the combat operators as much as possible. On the first day measurements included: soldiers rushing distances from anywhere between three to 30 meters with varying starting and stopping positions (i.e. standing to standing, standing to kneeling, prone to prone, etc) while wearing 30 kg of simulated fighting gear (helmet, body armor, weighted rubber M16, and backpack). This was followed by the US Marine Corps Combat Fitness Test (CFT), which consists of an 880-yard sprint; ammunition can lift, and maneuver under fire. The second day measurements consisted of: height, weight, body fat test using calipers, vertical jump, push-ups (in two minutes), sit & reach, horizontal jump, and the US Marine Corps Physical Fitness Test (PFT). The PFT consists of pull-ups (to exhaustion), sit-ups (in two minutes), and a timed three mile run. The subjects were given a score between one to three, with one as the highest passing class. This ranking system was in conjunction with the Marine Corps PFT classes of one to three. Upon analyzing the experimental data collection, the soldiers with class 1 scores are more likely to have faster rushing times for the three, six, and 15 meter rushing tasks than those that did not pass the Marine Corps PFT. Various performances of the physical fitness tasks were found to be correlated with the rushing performance ranks. According to the data, vertical jump, horizontal jumps, ammunition can lift and pull-ups were seen to correlate the highest.

In predicting survivability from the spreadsheet, three mathematical formulas were used based off of various rushing distances given specific travel velocities, enemy shooting accuracy, and shooting cadence. The first equation took into account distance/velocity - reaction = timed $_{\text{shooting.}}$ The second equation took into account Timed $_{\text{shooting}}$ * Shooting Cadence +1 = Shots. Lastly, third equation was Survival Probability = (1 – Accuracy) $^{\text{shots}}$. The investigators focused on four velocities from the spreadsheet from each distance group. The lowest velocity, median, and two highest velocity numbers from either the three meter kneeling to kneeling (1.224, 1.429, 1.639. 2.307 m/s), six meter kneeling to kneeling (1.893, 2.12, 2.5, 2.77 m/s), and 15 m standing to standing (3.106, 3.497, 4.05, 4.31 m/s) rushes were used to predict survivability. Blount and colleagues (2013) hypothesized that the velocity would not impact the results for the shortest and longest distances, but rather impact the survivability results for distances that were in between. This held to be true and was seen with velocities from the 15 m standing to standing rushes were used in the spreadsheet with 20% shooting accuracy, 0.5 s reaction time, and 0.5 shots/s shooting cadence. As expected those with higher rush velocity times showed a higher survivability rate and this was determined even for the shorter distances as seen in the three meter kneeling to kneeling rushes. In between the slowest and other three velocities for the same shooting accuracy, shooting cadence, and reaction time showed that maximum differences in survivability were seen between 25 and 30 meters.

In the agent based simulation, two generic scenarios were used similar to those encountered during combative operations. The first scenario mimicked a helicopter extraction where 13 soldiers with the same velocity rush towards a helicopter extraction point 15 m away, while two enemy soldiers fired their weapons. The second scenario consisted of two soldiers performing three rushes of three, six and six meters towards an enemy to get close enough to throw a grenade. Once again the velocities that were used to compare and differentiate to predict survivability were the velocities from the 15 m standing to standing (3.106, 3.497, 4.05, 4.31 m/s). The incorporation of simulated enemy fire was taken into account as well and broken up into shooting cadences (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5) and shooting accuracies (10%, 20%, and 30%). Success in the helicopter simulation was determined based upon casualties and was set at less than or equal to one casualty. During the grenade scenario, success was determined if the grenade was thrown at the enemy by one of the two soldiers. In this scenario the rush velocities that were used, were from the three meter kneeling to kneeling and six meter kneeling to kneeling. The rush velocities of these specific distances (three and six meters) were set once again at slow (1.224, 1.893 m/s), medium (1.429, 2.12 m/s), fast (1.639, 2.5), and very fast (2.307, 2.777 m/s). Shooting cadences mimicked that of the helicopter scenario as well (10%, 20%, and 30%). For both of these scenarios, over 500 runs were conducted to determine the probability of survivability. After computing all the results and formulating all the numbers, Blount and colleagues (2013) were able to predict the odds for survivability during the helicopter scenario at 10%, 20%, and 30% shooting accuracy. As the enemy shooting accuracy increased along with the shooting cadence the likeliness for survival converged despite the rushing velocity differences. However, rushing velocity overall was able to increase the probability of survival of the rusher in a single rush and in result may influence optimal performance/mission success. Blount and colleagues (2013) emphasizes the importance of physical fitness to combat a lack of rush velocities. All though there are numerous elements that were ignored that play apart in both positively and negatively affecting survivability (suppressive fire, casualty evacuation, etc), this investigation suggest the importance of being as physically fit and combat ready as possible with the purpose of improving specific operational performance such as rush velocities.

<u>Physical Fitness/Assessment for the Tactical Athlete:</u>

Hendrickson, Sharp, Alemany, Walker, Harman, Spiering, Hatfield, Yamamoto, Maresh, Kraemer and Nindl, 2010:

Combined Resistance and Endurance Training Improves Physical Capacity and Performance on Tactical Occupational Tasks

The objective of this study was to: evaluate the effectiveness of aerobic endurance (E), strength (R), and combined endurance and strength (CB) training for improving performance of tactical occupational tasks; determine if combined training interferes with performance enhancements of E or R alone; and to identify relationships between changes in maximal physical performance and occupational task performance. Fifty-six recreationally active women (18-26 years old) were randomly placed into four groups: R (n = 18), E (n = 13), CB (n = 15), control (n = 10).

The E group program was designed to improve the 3.2-km run time. The weekly training for this group was comprised of 20-30 min of continuous running at a prescribed target HR of 70-85% maximum HR, or interval running consisting of 400, 800, 1200, and 1600 m runs with 1:1 recovery time. The subjects in the R group trained on three alternating days between 40 and 63 minutes in duration. A non-linear periodized model was used where load and repetitions were varied on a weekly and/or daily basis. The program began after the first two weeks of pre-testing and familiarization. Weeks three through six consisted of "light" resistance days of 12 RM loads, "moderate" days using 8-10 RM loads, and "heavy" days using 6-8 RM loads. Progression occurred during weeks eight through11, "light" days utilized 12 RM loads, "moderate" days utilized 6-8 RM loads, and "heavy" days utilized 3-5 RM loads. The subjects in the CB group performed both E and the R programs on the same day. Three alternating days per week were used to utilized the same session and exercises as seen in the E and R groups. "Light" resistance training days corresponded to the interval sprint days in order to limit the intensity of either training session. Strength training sessions were always performed first. Lastly, control group were not required to do anything but testing.

Performances were measured pre-, mid-, and post- training for either a maximal time or maximal RM. These measurements are listed as followed: 1 RM bench press, 1 RM squat, bench press throw and squat jump peak power, VO_{2peak}, 3.2 km load carriage (LC, 32.7 kg), 3.2 km run, and repetitive lift and carry (RLC). The RLC and LC mimic military occupational lifting tasks. An obstacle course was also used to determine the influence of training programs on a set of sequential tasks. Lastly, a mannequin drag (61.4 kg over 50-m) was used to intend to mimic an emergency or medical personal rescuing a casualty.

This study demonstrated that the incorporation of both strength and endurance exercise in a short-time training program, similar in length to the Army's Basic Combat training course, promotes increase in both functional muscular strength and power. It also showed an increase in maximal rate of oxygen consumption. Most importantly, eight weeks of non-linear, periodized combined strength and endurance-training program resulted in increases in maximal strength, peak power, and aerobic capacity that were not different from either strength or endurance alone. Lastly, eight weeks of combined training improved performance in common tactical occupational tasks requiring both muscular strength and aerobic capacity to the same extent as both the strength and endurance group alone. In regards to the relationship between the occupational tests and maximal tests, a strong correlation was seen between an increase in the RLC with improvements in squat and bench 1 RM. Improvements in the 3.2-km load carry were moderately correlated to an increase in aerobic capacity. This study supports the importance of designing a training program for the tactical athlete that should include both strength and endurance.

Laing and Billing, 2011

Effect of Load Carriage on Performance of an Explosive, Anaerobic Military Task

The purpose of this study is to determine the impact on the performance of explosive, anaerobic military tasks due to load carriage and to identify any-sex based differences.

Seventeen Australian soldiers (5 female, 12 male) volunteered and were fully briefed regarding the experimental protocol and procedures. The seventeen subjects had minimal to no combat experience or experience wearing combat body armor (CBA). The task at hand that was being assessed was 5 30-m sprints unloaded (combat uniform and boots) vs. a combat fighting load consisting of a total of 21.6-kg (webbing, weapon, helmet, and combat body armor). The subject began on day with anthropometric measures along with performing the counter movement vertical jump tests in combat uniform and boots to assess lower body power. Upon completing of that first day, the soldiers returned a few days after to begin the BCD (5 x 30-m sprints) assessment. The two days of testing was separated by five days of recovery. Across the two days soldiers were both tested loaded with CBA (21.6 kg) and unloaded with just combat uniform and boots.

Prior to completing the BCD test; which consisted of 5 x 30-m sprints at 44 s intervals (which was standardized from the BCD development protocol) on a grass surface, the soldiers incorporated a standardized warm-up with relevant movement patterns that also played a part in their familiarization. Equipment checking was also necessary each morning prior to beginning to confirm weight accuracy. The participants were instructed to begin in the prone position and adopted the position 10 s before the sprint started. Each sprint was to be completed at the highest intensity possible with instruction to reach their maximum speed. Times were recorded at 5, 10, 15, 20 and 30-meter intervals. The mean of the five 30-m sprints were taken for overall performance of each condition to minimize any error effects of both the soldiers and the timing system operator from starting before or after the “beep”. Mean performance of the five sprints will also be used for analysis of the main effect of the 21.6-kg on the BCD performance. Laing and Billing (2011) used a two-way repeated measure ANOVA (order x condition) to detect any order effects across sprints 1-5, in both loaded and unloaded conditions. A two-way ANOVA (load x sex) was also used to diagnosis the effects of an additional 21.6-kg load on mean sprint time and to identify any significant sex-based differences or similarities

The results from this investigation support the findings that significant order effects were found across sprint repetitions one to five in the unloaded ($p < 0.05$) and loaded ($p < 0.01$) condition. According to Tukey's HSD, the first sprint repetition (8.3 ± 1.3 s) was significantly faster than sprints 3 (8.3 ± 1.5 s), 4 (8.4 ± 1.4 s), and 5 (8.3 ± 1.4 s). Repetition two of the sprints (8.1 ± 1.4 s) was statistically faster than sprint four. When analyzing results from the loaded conditions, an increase in the 30-m sprint mean times by 2.0 ± 0.6 s was observed due to the load (31.5%; $p < 0.01$) per sprint bout. However, 14 out of the 17 subjects met the performance criteria of nine seconds or less (which was standardized from the BCD development protocol) with a mean sprint time of 8.19 s. With this in mind, the implications of heavy fighting loads may significantly increase the risk of survivability due to its influence on the explosive anaerobic capabilities and the increase demand physiologically. When analyzing the results between the sexes, the females were found to be slower in both the unloaded and loaded conditions compared to males. Laing and Billing (2011) further analyzed time to completion by evaluating sprint times across components of the actual sprint and found that loss of time was most significant (51.7%) during the first 5-m, especially at the start due to the soldiers trying to overcome the initial inertia of the external load. Overall, no significant correlations were found between body mass and the BCD performances, but a significant correlation was found between vertical jump and the BCD performance, which pays dividends to the specific explosive nature of the vertical jump assessment.

This study supports the overall decrements of performance due to increased load. The importance of understanding the physiological demands of the combat operator is imperative and necessitates the right physical assessments and overall fitness.

Cuddy, Slivka, Hailes and Ruby, 2011

Factors of Trainability and Predictability Associated with Military Physical Fitness Test Success

The purpose of this study was to determine the trainability of the subjects using various training programs and to assess multiple factors that may be associated with success in passing a Special Operations Forces (SOF) physical fitness tests (PFT). One hundred thirty-five collegiate male subjects (age, 23.1 ± 4.6 years; height, 180.4 ± 7.2 cm; weight, 81.9 ± 14.3 k; body fat, 18.4 ± 7.7%) were organized into three different groups: run focused, calisthenics focus, or combined run and calisthenics. Data from 114 subjects were collected for the activity monitor analysis due to technical difficulties and scheduling issues. These subjects were training three times a week for a total of 12 weeks and were measured weekly on the PFT performance (pull-ups, sit-ups, push-ups, and 1.5-mile run time). Body composition and accelerometer activity patterns were used as measurements for both baseline and post-training. Every Wednesday the tests were conducted in this specific order: Pull-ups (max in one minute), sit-ups (max in two minutes), push-ups (max in two minutes), and 1.5 mile run (max effort).

The most recent PFT standards to achieve a passing score for selection into the US Air Force Special Operations Command (AFSOC) pipeline as a combat controller or pararescue jumper (PJ) are 2.41 km in ≤ 10:41-minute run, ≥ six pull-ups in one minute, ≥45 sit-ups in two minutes, and ≥45 push-ups in two minutes. These scores reflect the minimal requirements for AFSOC training pipeline qualification. To assess trainability potential, all 135 subjects were analyzed according to whether passing the initial pre testing and post testing requirements (Pass; n = 8), failed the initial PFT test but passed after the 12 weeks (train to pass; n = 24), and failed both times (fail; n = 103).

The data of this study suggests that subjects who ran well at the beginning of their training are more likely to achieve a passing score in 12 weeks compared with those who entered with a slower time. In addition, lower body fat percentage is highly correlated to PFT success and trainability (12.9 ± 4.7%), and candidates who participated in more vigorous physical activity (a minimum of 30 min/day) are more likely to achieve a passing score. This data supports the belief that certain candidates may be ruled out much earlier in the process and allow the SOF recruitment process to occur more efficiently.

Crawford, Fleishman, Abt, Sell, Lovalekar, Nagai, Deluzio, Rowe, McGrail and Lephart, 2011

Less Body Fat Improves Physical and Physiological Performance in Army Soldiers

The objective of this investigation was to compare physical and physiological fitness test performance between soldiers meeting the Department of Defense (DoD) body fat standard (≤ 18%) and those exceeding the standard (> 18%). Ninety-nine male soldiers from the 101st Airborne Air Assault unit participated in this research study. Soldiers were assigned to one of two groups. Group 1: ≤18% body fat (BF) or group 2: >18% BF. It was hypothesized that soldiers with less % BF (≤ 18%) would perform better on the physical and physiological fitness tests and the Army Physical Fitness Tests (APFT) compared to soldiers with higher % BF (> 18%). Physiological variables included: anaerobic power (PNAP), anaerobic capacity (MNAP), maximal oxygen consumption (VO_2max), peak isokinetic knee extension (AKE) and flexion (AKF), peak isokinetic shoulder internal (ASIR) and external rotation (ASER), and the Army Physical Fitness Tests (APFT).

Testing was performed on two days separated by 24 hours. Body composition, isokinetic strength tests, and anaerobic capacity were tested on day one and VO_2max was performed on day two. The components of the APFT were performed on that same day as well, but in a field setting.

The results of this study support the authors hypothesis that soldiers with similar amounts of fat free mass (FFM), those with less body fat and body weight performed better on tests of anaerobic and aerobic capacity, push-ups, and isokinetic knee and shoulder strength. Overall, individuals with excess % body fat are at a disadvantage and may possess physiological fitness and musculoskeletal strength deficits, reduced military readiness, and increased risk for unnecessary injury.

<u>Critical Velocity from Running</u>

The critical velocity (CV) test theoretically may allow us to predict the maximal running velocity that can be maintained for an extended period of time without fatiguing and even more so provide us with an individual's aerobic capabilities (Monod et al., 1965; Bull et al., 2008;

Jones et al., 2010; Fukuda et al., 2012). The anaerobic distance capacity (ADC), which is a measurement taken from the CV tests, is defined as the overall distance that may be covered using limited energy sources before the accumulation of fatigue related metabolites (Monod et al., 1965; Hill et al., 1999; Jones et al., 2010; Fukuda et al., 2012), which may provide us with an individual's anaerobic capabilities.

Housh, Cramer, Bull and Johnson, 2001

The Effect of Mathematical Modeling on Critical Velocity

The purpose of this investigation was to examine the effects of the five mathematical models on critical velocity (CV) estimates and corresponding oxygen consumption (VO_2), HR, and plasma lactate values. Ten male subjects [mean ± SD age = 22 ±2 yr., height = 179 ±4 cm, body mass = 77 ±8 kg] who exercise regularly, but not highly trained (< 25 km running a week) participated in this study. These subjects performed four CV tests to failure based on their fitness level. First subjects underwent a maximal test to determine $\dot{V}O_{2max}$ then performed four randomly ordered treadmill tests until exhaustion. Tests were conducted on two separate days at a selected pace that would induce fatigue between two and 12 min.

Two linear models [Linear total distance (L-TD)], linear velocity (L-V) and three non-linear models (nonlinear-2, nonlinear-3, exponential) based on cycle ergometry from previous literature, were used to estimate CV. CV estimations for the models are as follows: L-TD: r^2 = 0.99-1.0, SE = 0.1-0.5 km/hr; for L-V: r^2 = 0.94-.99, SE = 0.1-0.4 km/hr; nonlinear-2: r^2 = 0.94-0.99, SE = 0.1-1.4 km/hr; nonlinear-3: r^2 = 0.95-0.99, SE = 0.5-5.8 km/hr; and EXP: r^2 = 0.82-0.98, SE = 0.3-1.7 km/hr.

Overall, the nonlinear-3 produced significantly lower mean CV estimates compared with all the other models, which also resulted in the lowest estimates of CV for each subject. The EXP model produced the highest CV mean estimates and highest value for each subject. The L-TD, L-V and nonlinear-2 models resulted in very similar mean CV estimates (differed by only 0.2 km/h), while both the nonlinear-3 and EXP differed by 2.5 km/h. The three similar models also shared similarities among the CV, VO_2, HR and plasma lactate values in this present investigation that were similar to previous studies conducted by Housh and colleagues (1991) and Pepper and colleagues (1992). This suggests that although submaximal, an overestimation of a true fatigue threshold was seen.

Denadai, Gomide and Greco, 2005

The Relationship between Onset of Blood Lactate Accumulation, Critical Velocity, and Maximal Lactate Steady State in Soccer Players

The objective of this study was to analyze the velocity corresponding to the onset of blood lactate accumulation (OBLA) and critical velocity (CV) to determine maximal level steady state (MLSS) in soccer players. The goal was to examine both CV and OBLA for the aerobic evaluation of the soccer players. Twelve male (age 21.5 ± 1.0 years, height 178.0 ± 6.0 cm, body mass 71.0 ± 8.4 kg, body fat 12.0 ± 2.2%) professional elite soccer players participated in the study. A total of eight sessions were completed: an initial incremental treadmill test to determine OBLA followed by seven subsequent sessions to determine MLSS and CV. Both the determination of OBLA and MLSS were conducted on a treadmill with either a standard incremental test or five constant-velocity runs of 30-minute duration. However, for the MLSS the athletes initially ran at the OBLA velocity followed by two tests below and two tests above. For the CV, the subjects were instructed to run distances between 1500 and 3000-m on a 400-m track as fast as possible. The CV was calculated as the slope of the linear regressions of distance run versus time. Mean velocities of each tests are as followed: OBLA = 3.78, MLSS = 3.64, CV = 4.0 m/s.

Overall, there were no significant differences between OBLA and MLSS and between OBLA and CV. Statistically significant correlations were seen between OBLA and MLSS ($r = 0.80$), MLSS and CV ($r = 0.90$), and OBLA and CV ($r = 0.80$). Results from this study show that CV overestimates the MLSS and does not represent a sustainable steady-state exercise intensity. The data suggests the OBLA may be used to estimate the MLSS in soccer players, therefore making it a suitable aerobic fitness assessment more-so than CV. However, due to the close relationship that was seen between CV and MLSS, CV and OBLA and past research, the CV is a powerful predictor of endurance performance.

Bosquet, Duchene, Lecot, Dupont and Leger, 2006

V Max Estimate from Three-Parameter Critical Velocity Models: Validity and Impact on 800 m Running Performance

The purpose of this study was to investigate the validity of maximal velocity estimated from three parameter systems models, and to compare the predictive value of two- and three-parameter models for the 800 m run. Seventeen moderately to highly trained middle- and long-distance runners (VO_2 max = 66.54 ± 7.29 ml min^{-1} kg^{-1}) gave their written informed consent to participate in the study. The 800-m run was picked because of its aerobic nature, but also more importantly it provides a great anaerobic contribution as well. The subjects completed successively an incremental test (on a treadmill: velocity set at 12 km and increased by 1 km/h every two minutes until exhaustion), a maximum running velocity test (mean velocity over the last 10 m portion of a 40 m sprint), five constant velocity tests (CVT) and an 800-m performance time trial. All tests were separated by 72 hours and are performed within 6-8 weeks. Five system models (two three-parameter and three-two parameter) were used to compute V_{max} (three parameter models) critical velocity (CV), anaerobic running capacity (ARC) and the 800-m trial from times to exhaustion during CVT.

Mathematical modeling was used to fit the data from each constant velocity test to the five models used by House and colleagues (2001) to estimate CV. Individual parameters of each model were used to predict either velocity that subject could sustain during the time trials (equations 1, 3-5) or the duration needed to run the 800-m.Standard statistical methods were used during the statistical analysis for the calculation of means and standard deviations. Coefficients of determinations were calculated to examine the goodness of fit of the data to the models. General linear repeated measures were used to evaluate the differences in parameters from the five models.

Maximal velocity estimates were significantly lower than ($0.19 < Bias < 0.24$ m s^{-1}) and poorly associated ($0.44 < r < 0.94$) with actual maximal velocity (8.43 ± 0.33 m s^{-1}). CV explained 40-62% of the variance in the 800-m run. The combination of the CV with other parameters of each model to calculate the 800-m run resulted in clear improvements ($0.83 < r < 0.94$).

Bull, Housh, Johnson and Rana, 2008

Physiological Responses at Five Estimates of Critical Velocity

The purpose of this study was twofold: to compare critical velocity (CV) estimates from five mathematical models and to examine the oxygen uptake (VO_2) and heart rate (HR) responses during treadmill runs from the five estimates of CV. Ten healthy subjects (six males, four females, mean ± SD: age, 22 ± 2 year; mass, 75 ± 16 kg; height, 176 ± 11 cm; VO_{2max}, 51 ± 6 $ml/kg^{-1}min^{-1}$; HR_{max}, 195 ± 7 bpm) participated in this study. The subjects performed one incremental tests to determine VO_2max and four or five randomly ordered constant-velocity trials on a treadmill (lasting between 3 to 20 minutes) for the estimation of CV. Five mathematical models were used to estimate CV for each subject: linear regression of total distance versus time [Lin-TD: $TD = ARC + CV \times t$]; linear velocity model [Lin-V: $V = ARC \times (1/t) + CV$]; nonlinear-2 [$t = ARC/(V-CV)$]; Nonlinear-3 [$t = ARC/ (V/CV) – ARC/ (V_{max} – CV)$]; and the exponent model (EXP) [$V = CV + (V_{max} – CV) \exp(-t / \tau)$].

Continuous runs at CV were also performed. Up to five randomly ordered continuous runs were done by each subject at treadmill velocities corresponding to the five CV estimates. During these runs VO_2 was recorded (every 15-s) continuously, along with HR (every two min).

The results of this investigation indicate that there were significant mean differences between the CV estimates from the various CV models. The nonlinear-3 model produced CV estimates that were significantly ($P < 0.05$) less than the other four models. This was also seen in previous studies conducted by Housh et al (2001). The R^2 values from this study for CV (0.86 – 1.00) compared to those of previous studies (0.91-1.00) were consistent in estimating CV irrespective of the mathematical modeling.   50% of the subjects did not complete 60-min of running at their CV estimated from the nonlinear-3 model. Only one subject completed 60-min of running from the nonlinear-2 model and no subject completed 60-min of running at their CV estimated from the Lin-V, L-TD, or EXP models. According to these results, along with the subject's HR and VO_2 responses, blood lactate and ventilatory data from previous investigations (Housh et al, 2001) suggest that CV may not represent maximal running velocity that can be maintained for an extended period of time without fatigue. Therefore, CV would not represent the demarcation point between heavy and sever exercise domains (Bull et al, 2008-ref this article). This calls for potential future studies to increase the exercise intensities greater than those associated with the model or models that result in highest estimate of CV.

Clarke, Presland, Rattray and Pyne, 2014

Critical Velocity as a Measure of Aerobic Fitness in Women's Rugby Sevens

The objective of this study was to compare a field-based critical velocity (CV) running test to routine laboratory (VO_{2max}) test and field-based (Yo-Yo intermittent recovery test, Yo-Yo IR1) aerobic fitness test in women's rugby sevens (7's) players. The purpose was to determine the relationships between tests and their relevance to rugby 7's. Twenty-two females from the Nationals 7's squad (age 25 ± 5 yrs, mass 69 ± 7 kg, height 1.68 ± 0.06 m) underwent a series of field and laboratory based aerobic fitness tests overall several weeks. On the first visit the subjects completed both field tests (Yo-Yo and the CV run test). The second visit the players completed a treadmill VO_{2max} test and again the CV running test the following day.

The CV protocol consisted of the players performing maximal effort runs of 100, 400 and 1500 meters on a football 100-m field. The CV test was computed by the slope of the regression line when plotting distance (m) against time (s). All test scores, whether from the Yo-Yo test or the VO_{2max} test were converted to the same metric as the CV running test (m/s^{-1}). Results from the first testing session (Yo-Yo and CV) were compared to GPS game variables (championship games) including total distance (m), avg speed (m/s^{-1}), average m/min^{-1}, distance covered above 5 m/s^{-1} (high intensity running) and distance covered above 6 m/s^{-1} (sprinting).

The results of this study show that the CV test correlated with the Yo-Yo IR1 test along with all variables of the VO_{2max} test. However, mean variables between the tests were significantly different (Yo-Yo IR1: 4.3 ± 0.1 m/s^{-1}, VO_{2max}: 3.7 ± 0.3 m/s^{-1}, CV: 3.2 ± 0.3 m/s^{-1}). Average speed from the GPS data significantly correlated with both the Yo-Yo IR1 (r = 0.62, 0.10-0.87) and the CV test (r = 0.51, -0.06-0.83), while total game distance moderately correlated with the Yo-Yo IR1 (r = 0.49, -0.09-0.82) and the CV test (r = 0.36, -0.25-0.76). All in all, the authors were able to conclude that the CV test is an appropriate aerobic fitness and justifies the inclusion this test in women's rugby 7's. More so, the CV test may have an even greater benefit of aiding in the prescription of training in conjunction with the assessment of aerobic fitness.

Critical Velocity (CV) and Anaerobic Distance Capacity (ADC):

Fukuda, Smith, Kendall, Cramer and Stout, 2012

An Alternative Approach to the Army Physical Fitness Two-Mile Run Using Critical Velocity and Isoperformance Curves

The purpose of this study was to investigate the use of critical velocity (CV) and isoperformance curves as an alternative to the Army Physical Fitness Test (APFT) two-mile running test. Seventy-eight men (n= 39) and women (n= 39) (age: 22.1 ± 0.34 years; VO_2 max: 46.1 ± 0.82 mL/kg/min) participated in this study. The subjects completed a VO_{2maz} test and four running bouts till exhaustion at varying intensities on a treadmill.

To determine CV and Anaerobic running capacity (ARC/ADC) each participant VO_{2max} test times and the four treadmill velocities were selected as percentages of individual's peak velocity (PV) values, so that the run lasted between 3 and 20 minutes. CV and ARC were determined by the relationship between total distance and time-to-exhaustion when tracked during each exhaustive run. Isoperformance curves were also constructed for both men and women to correspond with two-mile run times from the APFT standards. Isoperformance curves are lines determined by two or more variables that can be used to demarcate between varying levels of performance (Jones, 2000; Morton, 2009). This allowed for the plotting of individual CV and ARC values in comparison to the isoperformance curves for the AFPT 2-mile run scores.

Each exhaustive run was timed and recorded until the subjects could no longer maintain the selected velocity and grasped the handrails to indicate exhaustion. A total of four runs were split between 2 days, with a 15-min rest period between each run. The intensities varied on the differing days (110% and 90% of PV on day 1 and 105% and 100% of PV on day 2). The L-TD model (TD = ARC + CV x t; where TD = total distance and t = time to exhaustion) was used to identify the ARC as the y-intercept and CV as the slope of the resulting regression line.

Predicted mean of VO_{2max} of sample A (n = 39) was 44.12 ± 6.49 and the actual observed mean was 44.12 ± 7.09. Predicted mean of VO_{2max} of sample B (n = 39) was 45.93 ± 6.29 compared to the observed mean that was 45.93 ± 7.04. These results provide the researchers with an understanding of the different variables from the CV that offer a method of predicting VO_{2max} that is comparable or an improvement upon the commonly utilized two-mile running test. It can be concluded that the CV test in conjunction with the isoperformance curves is a much more effective and even an alternative to the two-run test. This may be so in the ability to determine the physiological profiles of individuals, by combining all aspects of strength, endurance, and power that is neglected by the two-mile run. The ability to assess both aerobic and anaerobic training needs is extremely relevant for the tactical athlete, and the CV test described in this investigation may be most valuable for possible evaluations of Special Ops assessment/evaluations or predictability for operational relevant tasks.

Zagatto, Kalva-Filhoo, Loures, Kaminagakure, Redkva and Papoti, 2013

Anaerobic Running Capacity Determined from the Critical Velocity Model is not Significantly Associated with Maximal Accumulated Oxygen Deficit in Army Runners

The objective of this investigation was to verify whether there is an association between anaerobic running capacity (ARC/ADC) values, estimated from two-parameter models, and maximal accumulated oxygen deficit (MAOD) in army runners. Eleven trained middle- and long-distance (800-5000 m) runners who are members of the armed forces (Brazil) participated in this study (20 ± 1 years; 65.6 ± 0.9 kg; and 1.7 ± 0.0 m height). All subjects participated in military competitions and had a weekly training routine of 6 d/wk with a volume of approximately 70-85 km/wk.

The subjects had to complete a GXT, an MAOD test, and a critical velocity (CV) test, which were all performed on a motorized treadmill. This was all completed within ten days. For the GXT the subjects began at 12 km/h and every 3-min 1 km/h was increased until voluntary exhaustion. VO_{2max} was determined based off of last 30 s. During the MAOD, subjects performed five 7-min submaximal running bouts corresponding to 50, 55, 60, 70 and 80% of vVO_{2max}. MAOD was determined based off the lowest velocity at which maximal oxygen uptake was achieved (vVO_{2max}), which was 110%. A minimum of 24 hours of recovery times was maintained between each supramaximal test. During the CV test subjects randomly performed three exercise bouts until exhaustion (tlim) at intensities of 100, 110 and 120% of vVO_{2max}. Three models were used to estimate ARC from the CV test. Similar to previous studies, the three models used were: nonlinear-2 [tlim = ARC/ (v-cv)], L-D model [D = (CV x tlim) + ARC], and a linear velocity model [V = (ARC x $tlim^{-1}$) + CV].

This study suggests that, in runners, there is no significant correlation between ARC and the anaerobic capacity as expressed through the MAOD. However, the results do indicate that the three mathematical formulas showed good adjustment (correlation from 0.95 to 1.00) for intensities between 100% and 120% vVO_{2max}. The ARC values were 240.4 ± 18.6 m from the linear velocity- inverse time model, 254.0 ± 13.0 m from the L-D time model, and 275.2 ± 9.1 m from the nonlinear-2 parameter model. CV values were 3.91 ± 0.07 m/s, 3.86 ± 0.08 m/s and 3.80 ± 0.09 m/s. Value differences were significantly seen ($P < 0.05$) between the ARC and CV when compared between the nonlinear-2 model and velocity-inverse time model. The authors concluded that estimated ARC does not correlated with MAOD and should be considered as an anaerobic measure of capacity for treadmill running.

<u>Critical Velocity and 3MT All-Out Tests:</u>

Pettitt, Jamnick and Clark, 2012

3-Min All-Out Exercise Test for Running

The objectives of this study was to examine the efficacy of a running a 3-min all out running tests while using a global positioning system (GPS) to predict outdoor racing performances. Fourteen collegiate female distance runners (age: 19 ± 1yr, VO_2 55 ± 4ml/kg/min) performed a 3-min all-out run outdoors on a track. The wearing of the GPS allowed for precise accuracy of the measurements to the nearest meter. GPS was also used to determine the parameters of CS and D'. Theoretically, the anaerobic distance capacity (ADC) or running distance (ARC) [running at a speed above the CV], is used up at two and half minutes and critical speed/velocity (CS) will be the mean speed over the final 30s [$D' = t\,(S_{150s} – CS)$: D' is the ADC/ARC, t is the TTE, and S is the mean speed from the first two and a half minutes]. Pettitt et al briefed their subjects on maximal exertion to ensure that subjects did not pace themselves over the 3-min all-out test.

The authors were able to conclude that the 3-min all-out run may provide a comprehensive analysis of a runner's physiological status and most importantly be able to predict race time for distances ranging from 1000m to 5000m. They saw that runners were higher D’ values compared to lower D’ values, ran at higher speeds relative to their CS/CV. The 3-min all out run appears to be equally effective for running, in comparison to cycling, and does not require a preliminary GXT before its implementation. In actuality, data from the 3-min all-out run may be used to produce custom GXT’s and the combination of both may provide a comprehensive analysis of a runner’s physiological status.

Broxterman, Ade, Poole, Harms and Barstow, 2013

A Single Test for Determination of Parameters of the Speed-Time Relationship for Running

The purpose of this study was to determine if a single all-out running test (3-min all-out run) can accurately measure CS and D’. Broxterman and colleagues looked predominately at the end test speed (final 30 sec of a single test) and D’ would not differ significantly from the traditional CS protocol and that the distance above end-test speed (DES) would not differ significantly from the traditional D’ protocol. Seven healthy and fit subjects (< 150min marathon; 4 men and 3 women, 25.3 ± 3.4 yrs.) participated in this study. It was required of the participants to arrive to the human performance lab eight times separated by at least 24hrs. Subjects had to begin with an incremental GXT on a treadmill to determine VO_{2max} and the speed at VO_{2max} (S_{peak}). Three separate constant speed runs (90-120% S_{peak}) to exhaustion were performed to determine the speed time relationship. For the determination of CS and D’, a two-parameter linear speed-1/time model was used: S= (D’/t) + CS (S = speed, t = TTE, CS = critical speed, D’ = distance covered above CS (ADC or ARD). Subjects then performed two validation trials at constant speeds slightly above and below their CS and a 3-min all-out run test to determine both ES and DES.

The major finding of this examination supported both hypothesis that a single 3-min all-out run may accurately predict CS determined from the speed-1/time model and that DES was not significantly different that the speed-1/time D'. However caution is warranted due to DES being underestimated in 5 of 7 subjects.

Clarke, West, Reynolds, Murray and Pettitt, 2013

Applying the Critical Velocity Model for an Off-Season Interval Training Program

The purpose of this study was to evaluate the effects of 2 separate high intensity interval training (HIIT) regiments aimed at enhancing critical velocity (CV) or displacement work capacity of the body above CV (D'). The author's main question was if the CV model may be applied to an off-season interval training program. A group of sixteen female soccer players (age = 19 ± 1 yrs, height = 168 ± 6 cm, mass = 61 ± 6 kg) completing one of two different HIIT regimes: short group (n = 6) completing high velocities (V) and shorter time (t) configurations, and a long group (n = 10) completing lower V, longer t configurations. Both groups trained two days a week for four weeks.

A 3-min all-out run (Pettitt et al, 2013) was used to determine the CV and D' parameters. The players were ranked at pretesting and based on those results/training needs they were assigned to either a group aimed at increasing CV or D'. A 3-min all-out run was also used during the post-testing to determine the difference between groups for changes in CV and D'. The 3-min all-out run was conducted on an indoor, 200-m field house track and was recorded using a digital video at a rate of 30 Hz. CV was calculated from the average velocity of the last 30-s, and D' was calculated by subtracting the average velocity of the first 150-s by the CV and then multiplying by 150-s [D' = 150s (V_{150} –CV)]. Interval times were also calculated based off the subjects CV and D' (see interval prescription for interval equations) and were assigned to either short or long groups based on teams mean CV and D'.

The principal findings of this study support that four weeks of HIIT were sufficient to evoke moderate improvements in CV in trained soccer players. It was also seen that both groups experienced reductions in D', which necessitates shorter more intense HIIT bouts to evoke improvements in D'.

CHAPTER III: METHODS

Subjects

Eighteen male soldiers (age: 19.9 ± 0.8 years; height: 177.6 ± 6.6 cm; body mass: 74.1 ± 5.8 kg; BMI: 23.52 ± 1.63) from an elite combat Special Force unit of the Israel Defense Forces (IDF) volunteered to participate in this study examining the relationship between a 3-min all-out run to operational combat specific tasks (2.5-km run, 50-m casualty carry (CC) and 30-m repeated sprints and rush shooting, RPTDS). Following an explanation of all procedures, risks and benefits, each participant provided his informed consent to participate in the study. The Helsinki committee of the IDF Medical Corp approved this research study.

Testing Protocol

This investigation was conducted at the unit's training facilities, under the unit's regular training protocols and safety regulations. Due to the time of the year (summer), the testing protocol began before sunrise to prevent any heat issues that may arise due to the intense testing protocol. In addition, in accordance with the IDF's environmental safety protocols, heat conditions were monitored to ensure exercise was conducted below the specific heat index as the testing progressed into the late morning. During the testing day, anthropometrics were collected and participants performed military relevant tasks that included a 2.5 km run, a 50-m CC and RPTDS. These assessments were based upon previously published investigations examining combat specific measures (Nindl et al. 2002, Harman et al. 2008). In addition, the subjects performed a 3-min all-out run, which included assessment of CV and ADC. Each test assessment was separated by 15 minutes in order to allow for sufficient recovery between each test. Testing order was as follows:

2.5-km run, 3-min all-out run, 50-m CC and RPTDS. Subjects had been previously trained and familiarized on all of the combat specific tasks and 3-min all-out run prior to the study. The 3-min all-out run and the 2.5-km run were performed on an asphalt road. The participants were dressed in shorts, T-shirt and running shoes for the 2.5-km run, 3-min all-out run, and the 50-m CC.

Performance Measurements

3-Min All-Out Run

All participants were provided with an individual global positioning system (GPS) device that they wore in a vest unMaximal derneath their shirt. The GPS was positioned in a posterior pocket on the vest situated between the participant's scapulae in the upper-thoracic spine region. Data from the GPS units (time, total distance covered and raw velocity) were downloaded from the GPS receiver/transmitters. All GPS data was analyzed using software provided by the manufacturer (MinimaxX, V4.3, Catapult Innovations, Victoria, Australia) and then exported into a customized LabVIEW (National Instruments, Austin, TX) program for further analysis. Estimates of CV and ADC from the 3-min all-out run were determined from the downloaded GPS data with CV calculated as the average velocity of the final 30 s of the run and ADC as the velocity-time integral above CV (see figure 1). During the all-out run tests, the participants were briefed on the importance of giving maximal effort. Verbal encouragement was provided; however, subjects were not informed of the time-elapsed or time remaining in order to discourage pacing.

Reliability of 3-minute all-out run using the GPS technology was examined with pilot data from our laboratory. Ten recreationally trained participants (between 20-27 years old) performed the 3-minute all-out run on a 400-m track with the GPS system and analyzed using LabVIEW similar to methods used in the current study. Intraclass correlation coefficients were 0.96 for CV (SEM = 0.16-m/s, mean = 3.3 ± 1.07 m/s) and 0.89 for ADC (SEM = 18.04-m, mean = 151.17 ± 79.07-m).

2.5 km run

This test has been previously used to simulate a soldier's rapid approach to the battlefield (Harman et al., 2008). Participants performed 2.5 km run still instrumented with the GPS device. Average velocity and time to complete the 2.5-km run were downloaded from the GPS receiver/transmitters.

50-m Casualty Carry

The 50-m casualty carry simulates the rescuing of a wounded soldier on the battlefield. All participants began the test with a 60 kg manikin on their back, using a fireman's carry. On a verbal command, the participant sprinted with the manikin to a cone 25-m away and returned to the starting position. All sprints were performed on a sand and dirt surface. All timing was performed with a handheld stopwatch, by the same investigator, for all sprint trials and all participants.

Repeated Sprints with Combat Gear and Rush Shooting

This test simulated the repeated sprints and shooting engagement often encountered within an urban battlefield, also termed "rush shooting" (Harman et al., 2008). Each participant began in a two-point stance at the edge of the firing range in full combat gear (combat vest with ammunition and helmet). Upon a verbal command, the participant sprinted around a cone 15-m away and returned to the firing range. Each participant then sprinted to a designated spot and lay prone on the ground as quickly as possible and delivered 3 shots to a target 30-m away. Participants had 5 s to deliver three shots at the target. Upon completion of the three shots, each participant pivoted and returned to the starting line and repeated the sprint and shooting sequence. A total of five sprint and shooting rounds were completed (a total of five 30-m sprints and 15 shots). For safety purposes, participants did not sprint with their assault rifle. All sprints were performed on a sand and dirt surface similar to the 50-m CC. All timing was performed with the same investigator using a stopwatch for all sprint trials for each participant.

Statistical Analysis:

Pearson product-moment correlations were used to examine the relationship between the 3-min all out sprint (CV and ADC) and the operational combat specific tasks (2.5km run, 50m casualty carry, and repeated sprints). Partial correlations that examined the effects of BMI on the relationship between the 3-min all out sprint (CV and ADC) and operational combat specific tasks were also evaluated. Stepwise regression analysis was performed to determine the relative importance of CV and ADC in combat specific tasks. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using SPSS (Version 21.0). Data are reported as mean ± SD.

CHAPTER IV: RESULTS

Physical Characteristics and Performance Measurements:

The physical characteristics of the participants and performance measurements from the 3-min all-out run (CV, ADC, 3-min TD), and combat specific tasks (2.5-km run time, AVG V 2.5-km, 50-m CC, RPTDS) can be observed in Table 1. The association between CV and ADC of the 3-min all-out run, to combat specific tasks and BMI of the participants are depicted in Table 2. CV exhibited significant negative correlations with the 2.5-km run time (r = - 0.62, p = .008), and RPTDS (r = - 0.71, p = .001). In addition, CV was positively correlated with the average velocity during the 2.5- km run (r = 0.64, p = .006). However, CV did not show any correlation with the 50-m casualty carry run (r = -0.31, p = .204). ADC was significantly related with the average velocity of the 2.5-km run (r = -.049, p = .046) but with no other combat specific tasks. Lastly, BMI showed a significant positive correlation with RPTDS (r = 0.58, p = .014).

Table 3 shows the partial correlation coefficients between CV and the combat specific tasks, controlling for BMI. When controlling for BMI, CV maintained its significant negative correlation with both 2.5-km run time (r = -0.55, p = .033) and RPTDS (r = - 0.7, p = .004), and a positive correlation with the average velocity of the 2.5-km run (r = 0.57, p = .025).

Stepwise regression analysis examined CV, ADC and BMI as independent variables with each combat specific task as the dependent variable. Results of the analysis identified CV as the only significant performance measure associated with the 2.5-km run (SEE = 27.8; R^2 = 0.40).

Furthermore, BMI and CV measures were significant predictors of RPTDS (SEE = 0.16; R^2 = 0.67) (see Table 4).

CHAPTER V: DISCUSSION

To the best of our knowledge this is the first study to examine the relationship between CV and ADC as measured from a GPS based 3-minute all-out run and combat specific tasks (CST) in an elite special operations unit. Our main findings indicate that CV was highly related to performance during the CST, including the 2.5-km run and RPTDS, but not the 50-m CC.

Determining physical performance attributes among military personnel is vital for selection of personnel for special operation units, as well as identifying the physical needs necessary for successful combat performance (Harman et al. 2008). The understanding of the physical demands of the combat soldier provides for a more effective strength and conditioning program. Most performance assessments conducted on soldiers entering basic training or selection for special operations units have followed the standardized Army Physical Fitness Test (APFT), which focuses on aerobic capacity and muscle endurance (Cuddy et al., 2011, Heinrich et al., 2012). Aharoney et al. (2008) have suggested that Special Forces training is more demanding than that undertaken by elite athletes. Cuddy and colleagues (2011) determined that out of 135 recruits, the soldiers who performed well in the Air Force Special Operations Command (AFSOC) physical fitness test (2.41 km in ≤ 10:41-minute run, ≥ 6 pull-ups in 1 minute, ≥ 45 sit-ups in 2 minutes, and ≥ 45 push-ups in 2 minutes) at the beginning of their training, and had a body fat percentage ≤ 12.9 % were more likely to qualify into the AFSOC pipeline as a combat controller or pararescue jumper compared with those who entered with slower times and had higher body fat percentages. Though it may suffice as basic fitness standards for soldiers, some have strongly argued that the APFT is neither a relevant or adequate fitness assessment to test combat readiness (Olson et al., 2011; Heinrich et al., 2012). The potential benefit of assessing performance in a 3-min all-out run may provide information on both the aerobic (CV) and anaerobic (ADC) capabilities of the tactical athlete.

The results of this present study suggest that the CV by itself may not only be related to an individual's aerobic capability, but also provide an indication of their anaerobic performance as well. Previous research has demonstrated that high levels of aerobic fitness during a predominantly anaerobic activity, such as repeated sprints can influence recovery rates during repeated bouts of high intensity exercise (Plisk, 1991; Hoffman, 1997; Glaister, 2005). This relationship has been attributed to a reliance on oxygen-dependent processes in PCr replenishment and the removal of accumulated intracellular inorganic phosphates (Pi) (Glaister, 2005). Past research has indicated that replacing long bouts of exercise with short-duration, high-intensity intervals often will lead to improvements in the aerobic capability of the individual, due to the delay of muscle fatigue (Weston et al., 1997; Glaister, 2005; Kendall et al., 2009). As such, the lower intensity periods between each sprint provides an opportunity for greater recovery. This may explain why CV and not ADC was observed to significantly correlate with RPTDS performance. Interestingly, the average CV of the elite special force operators examined in this study was 4.09 $m \cdot s^{-1}$. This is similar to the CV reported in professional soccer players using the slope of the linear regression model measuring distance run versus time, which identified average CV at 4.0 $m \cdot s^{-1}$ (Denadai et al., 2005). These similarities in CV draw physiological parallels between the two groups for the importance of both repeated sprint ability and endurance performance, which are crucial components of both soccer players and the tactical athletes (Knapik el al., 1990; Hoffman, 1997; Aziz et al., 2000; Helgerud et al., 2001; Harman et al., 2008; Demaio et al., 2009; Hendrickson et al., 2009). These results are also similar to a recent study by Beck and colleagues (2014) that showed no relationship between anaerobic working capacity (AWC) and repeated sprints in soldiers. Still, the ability to perform repeated sprints is also closely related to specific anaerobic processes such as anaerobic glycolysis (Glaister et al 2008), buffering capacity (Bishop et al., 2004; Bishop et al., 2006; Kendall et al., 2009) and muscle glycogen concentration (Gaitanos et al., 1993). Our results demonstrated that a greater CV during the 3-min all-out run was associated with a faster time to complete the 2.5-km run and a greater performance in RPTDS. These findings are in agreement with Fukuda and colleagues (2012) which supported the use of CV as an alternative approach to the APFT 2-mile run. The possibility of pacing during a 2-mile event or any other endurance event draws many questions regarding the tactical athlete's true fitness evaluation. The significant correlation between CV and both the 2.5-km run and RPTDS during this study using the 3-min all-out run further strengthens this alternative approach for assessing both aerobic and anaerobic capabilities. The significant correlation between CV and average velocity ($r = 0.64$) of the 2.5-km run observed in this study appears to be indicative of a greater time spent at higher velocities during the 2.5-km run. These results are also supported by a recent investigation by Ade and colleagues (2014). They reported significant associations between CV and NASA-based physical ability field tests (included: ladder climb, agility cones, 4.5-m stair climb, lateral climb, 4.5-kg box lift, and a step-over 40-cm hurdlers) ($r = 0.66- 0.82$, $P < 0.001$) and a 10-km walkback test ($r = 0.64-0.85$, $P < 0.001$). Thus, the ability to perform at or maintain higher velocities during battlefield approaches is a physical attribute that is consistent with CST performance, and demonstrates a specific level of conditioning needed for combat personnel. This is further supported by Blount and colleagues (2013) who reported that higher repeated sprint “rush” velocities were indicative of a higher survivability rate for tactical operators within a simulated urban warfare scenario.

We were unable to see any relationship between the 50-m CC, and any of the measurements. This is likely related to the large strength/power component of carrying ~80% of one’s body weight. This along with many other high intensity and short duration combat specific tasks (wall climbs, house to house sprints, agility, lifting etc.), highlights the importance of strength and power development for combat personnel (Kraemer et al., 2004; Laing et al., 2011; Blount et al., 2013).

Stepwise regression analysis identified CV and BMI as significant predictors of RPTDS performance more so than CV alone. Body composition is an important measure used by the military to assess optimal physical fitness, operational readiness, and, in some regards, for unit selection (Sharp et al., 2008; Williamson et al., 2009; Crawford et al., 2011; Cuddy et al., 2011). Excessive fat mass has been associated with impaired aerobic fitness (Friedl et al., 2004) and specific military performance tasks that involve both strength and aerobic components (Knapik et al., 2005; Sharp et al., 2008; Ricciardi et al., 2008). Our results when factoring in BMI, support previous studies (Lyons et al., 2005; Cuddy et al., 2011; Crawford et al., 2011), suggesting that a lower BMI is associated with better 2.5-km run and RPTDS performance.

Practical Applications:

Using the 3-min all-out run as an assessment tool offers an efficient and simple method of evaluating both aerobic and anaerobic capabilities (CV and ADC) of large groups of participants. As such, the 3-min all-out run may be conducive to the military where the logistics of testing large groups of soldiers needs to be factored into a limited availability of time. Future research should focus on looking at a larger sample to predict operational performance using the 3-min all-out run and additional combat specific tasks (i.e. 400-m combat gear sprint, combat gear distance run, jump performances, obstacle courses, etc.). Due to its versatility in providing both aerobic (CV) and anaerobic (ADC) capabilities, the 3-min all-out run may be a useful alternative to standard metabolic/performance testing batteries. Future research using the 3-min all-out run should examine its potential utility as a criterion for unit selection, and predictor of combat readiness.

APPENDIX A: TABLES

Table 1. Physical characteristics, 3-min all-out run, combat specific tasks (n = 18)

	Mean ± SD
Physical Characteristics	
Age (years)	19.9 ± 0.8
Height (cm)	177.6 ± 6.6
Mass (kg)	74.1 ± 5.8
BMI (kg/m²)	23.52 ± 1.63
3-min All-Out Run:	
CV (m/s)	4.09 ± 0.41
ADC (m)	78.56 ± 21.94
3-min TD (m)	789.64 ± 54.49
Combat Specific Tasks:	
2.5-km run (sec)	612.59 ± 34.38
AVG V 2.5-km run (m/s)	4.07 ± 0.23
50-m CC (sec)	15.09 ± 0.92
RPTDS (sec)	8.01 ± 0.26

BMI body mass index, CV = critical velocity, ADC = anaerobic distance capacity, TD total distance, AVG V = average velocity, CC= casualty carry, RPTDS = 30-m repeated sprints with “rush” shooting

Table 2. Correlation coefficients between 3-min all-out run, combat specific tasks and BMI (n = 18)

	CV	ADC	3-min TD	2.5-km run time	AVG V 2.5-km run	50-m CC	RPTDS	BMI
CV	-	-0.73**	0.92**	-0.62**	0.64**	-0.31	-0.71**	-0.25
ADC		-	-0.44	0.46	-0.49*	0.16	0.27	0.03
3-min TD			-	-0.55*	0.56*	-0.31	-0.81**	-0.29
2.5-km run time				-	-.99**	0.36	0.51*	0.40
AVG V 2.5-km run					-	-0.35	-0.51*	-0.39
50-m CC						-	0.14	-0.11
RPTDS							-	0.58*
BMI								-

CV = critical velocity, ADC = anaerobic distance capacity, TD = total distance CC = casualty carry, RPTDS = 30-m repeated sprints with “rush” shooting, BMI = body mass index

Statistical significance: * $P < 0.05$, ** $P < 0.01$

Table 3. Partial correlations coefficients between CV and Combat Specific Tasks (CST) (n = 18)

	Control Variable	2.5-km run time	AVG V 2.5-km	50-m CC	RPTDS
CV	BMI	- 0.55*	0.57*	- 0.29	- 0.7**

CV = critical velocity, CC= casualty carry, RPTDS = 30-m repeated sprints with "rush" shooting, BMI = body mass index   Statistical significance: * P < 0.05, ** P < 0.01

Table 4. Factors associated with combat specific tasks on stepwise regression analysis (n = 18)

Dependent Variables	Independent Variables	Coefficient	Standardized coefficient	t value	p value	95% Confidence interval	
						Lower	Upper
2.5-km run time (sec)	CV (m/s)	-51.3	-0.6	-3.1	< 0.01	-86.9	-15.7
RPTDS (sec)	CV (m/s)	-0.38	-0.6	-3.8	< 0.01	-0.59	-0.16
	BMI (kg/m²)	0.07	0.43	2.7	< 0.05	0.01	0.12

CV = critical velocity, RPTDS = 30-m repeated sprints with "rush" shooting, BMI = body mass index

APPENDIX B: FIGURES

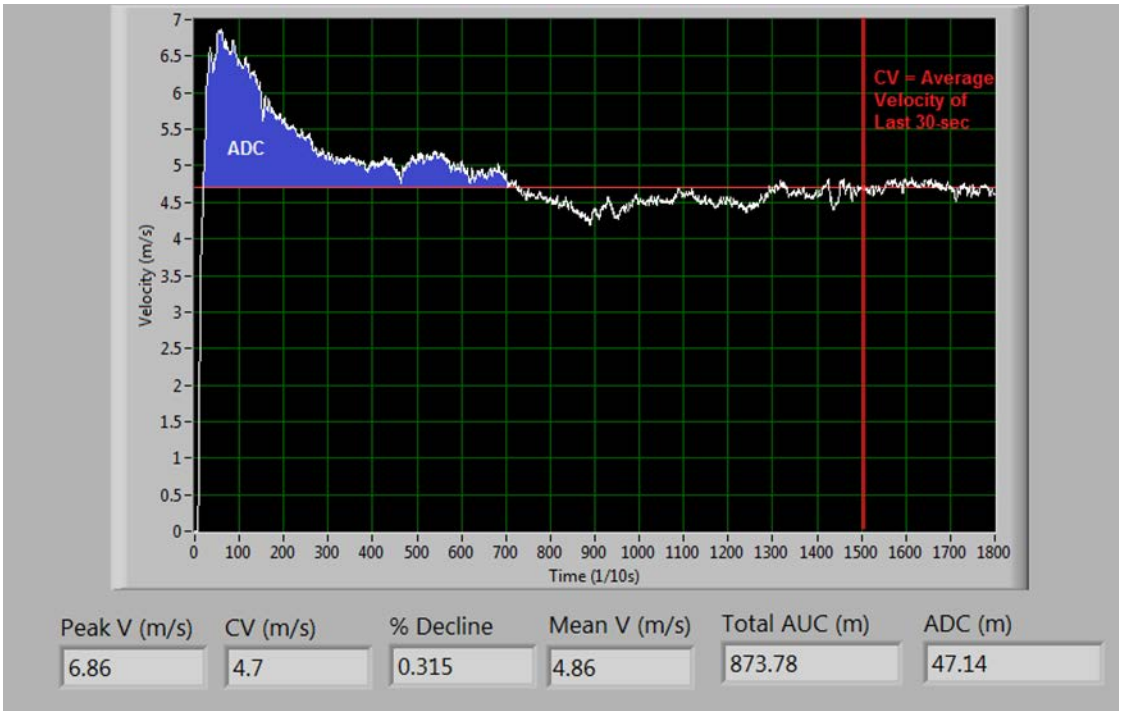

Figure 1: 3-min All-Out run: CV is the average velocity of the last 30 sec as seen in red.

APPENDIX C: IRB APPROVAL

UCF IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2012 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

From: UCF Institutional Review Board

FWA00000351, Exp. 7/24/2019, IRB00001138

To: Mattan Hoffman and Dr. Jeffrey Stout (Faculty Advisor)

Date: January 15, 2015

Study Title: Critical Velocity Is Associated with Combat Specific Performance Measures in a Special Forces Unit

Thank you for submitting the information regarding your Master's thesis, as requested by the UCF College of Graduate Studies. As you know, the IRB cannot approve your research because it was already completed prior to UCF-IRB review.

Per federal regulations and UCF policy, when UCF is engaged in human subject's research, the study must be submitted to UCF-IRB for review determination. It would violate Federal statue and university policy to approve a study after it is completed. When research is conducted by a UCF employee or student, the university is engaged. This may require dual review if another institution is involved in the study. In such a case, the PI (student or faculty advisor) must contact the UCF-IRB prior to beginning the research since supporting documents must be created and signed to enable one IRB to rely upon the other, if that is appropriate. In such cases, if it is a student he/she must submit a study application and protocol in iRIS explaining where he/she is obtaining the data, whether personal identifiers will be obtained, and if so, whether the researcher will record identifiers as part of his/her analysis. If this is done prior to conducting the research, the IRB could have made one of the following research determinations: "not human subjects research," "Exempt," or "Expedited." While the Israeli institution's IRB was required for the larger study that involved interaction with the human subjects, it is the UCF-IRB that needed to review and approve the thesis research that was conducted for the Master's degree.

Unfortunately, in your case this was not done and your thesis was not submitted to the UCF-IRB prior to beginning the research. Your faculty advisor, Dr. Jeffrey Stout, has explained that this was unintentional. Dr. Stout believed that since he had International IRB approval for a larger study (for which this research was a part), that UCF-IRB approval was not required. Since the International IRB approval documents for the larger study were written in Hebrew, an English translation was requested.

Upon examination of the translation it was noted that the supportive documentation did not match the research study and differed in title, purpose, design and procedure. In order for UCFIRB to have approved this study additional documentation would have been required prior to starting your research.

Specific information that outlines the role of this study as part of a larger study, ensuring participant consent for this portion of the study, permission to conduct this sub-part of the study, and clarification related to the generalizability and whether the data could be used in future publications would have been required. Once these clarifications and supportive documentation had been received, the study could have been approved by the UCFIRB for expedited review (category # 4 and 7). NOTE: If the initial study had already taken place and Mattan Hoffman obtained data/records for retrospective review, the IRB determination might have been Exempt, category #4, or Expedited, category #5).

If you have questions, please either call me directly or phone the IRB office at 407-823-2901.

Sincerely,

Sophia F. Dziegielewski, Ph.D., LCSW

Professor, School of Social Work

Chair, University of Central Florida, Institutional Review Board

Editor, Journal of Social Service Research

University of Central Florida

P.O. Box 163358

Orlando, FL 32816-3358

Social Work Office: 407-823-6342

IRB Office: 407-823-0884

FAX: 407-823-5697

Sophia.Dziegielewski@ucf.edu

cc: IRB file, Faculty Advisor, Graduate Studies, Thomas O'Neal

ISRAEL IRB TRANSLATION

Regulation: Recruitment for Medical Research in Humans	Date
Forms	

Form 7 – Page 1 of 3
Administrative Approval Helsinki Committee for Medical Research on Humans The effect of 28 days of beta-alanine ingestion on military performance (physical and cognitive) in a Special Forces unit. IDF-1267-2013

Date: June 26, 2013

To Dr. XXXX Primary Investigator
Commander XXXXXXXX unit

Dear Dr./Professor

Subject: Study Approval for Clinical Study on Humans

In response to your request of June 22, 2013 the approval for study number IDF-1267-2013 has been approved

NIH Number	Ministry of Health Number	Helsinki Committee Number: IDF-1267-2013
Title of Study: The effect of 28 days of beta-alanine ingestion on military performance (physical and cognitive) in a Special Forces unit.		
Area of Study limitation: None		Area of Study limitation: None
Date: June 22, 2013	Copy 2.O	Protocol number: 1267-2013
Date: June 22, 2013		Agreement Form: Copy 2.0
Date		Investigators Brochure (if any): Copy:
Unit: xxx		Name of the Investigator: Dr. XXXXXX
Name and address of the representative in Israel:		Name of the Study Administrator: Dr. XXXXX

This agreement is valid from the general administrator of the Ministry of Health to provide approval to administer a clinical study in humans, in the Medical Corps following the request granted by the

Helsinki committee on June 22, 2013. It is convinced that the study is conducted within the principles of the declaration of Helsinki and Public Health (clinical studies in humans) from 1980, and that the study protocol, principle investigator and the facility meet the requirements for clinical trials in humans.

Regulation: Recruitment for Medical Research in Humans	Date
Forms	

Form 7 – Page 2 of 3
Administrative Approval Helsinki Committee for Medical Research on Humans The effect of 28 days of beta-alanine ingestion on military performance (physical and cognitive) in a Special Forces unit. IDF-1267-2013

I confirm the execution of the study, subject to the following conditions:

Date: June 26, 2013

Conditions of Approval

A. The clinical trial will be carried out according to the principles of the Declaration of Helsinki and in accordance with the procedure requirements of medical experiments on humans in Israel in 2005 and the requirements of international regulations.
B. The treatment will be given only after explaining to the participant or his legal representative and signed the informed consent form that came with the application.
C. Any change or deviation from the protocol requires written approval of the ethics committee of the institution clinics or the Ministry of Health.
D. The principle investigator for the clinical trial will report to the ethics committee of the facility on all major unusual incidents (SAE) that occur during the study (as specified in Section 15.1.1 procedures), or the termination of the study to the institutional ethics committee will examine the report and provide its opinion to the Ministry of Health.
E. Extending the validity of the clinical trial: Two months to conduct the approved study. It is required for the principal investigator to provide a report regarding the progression of the study to the Helsinki committee of the Medical Corps. The committee will notify on its decision to extend the time for data collection. If approved, the administrator will issue a new approval.
F. At the end of the study the principle investigator will submit to the Helsinki committee the final report on the results of the study.
G. The approval provided to the principle investigator and the medical institute only and cannot be transferred to another individual.
H. Clinical studies that involve the provision of services: medical tests or provision of devices, pharmaceuticals or implants, requires the principle investigator to inform the physician responsible for the health of the subjects on the use of such products.

I. It is not allowed to reveal any information about the clinical trial in the mass media, such as newspapers, radio or television, internet, advertising in the scientific journals or conferences, except for recruitment advertising for the study.
J. Study materials (investigational product – IP) or other supplies necessary for the clinical studies is the responsibility of the initiator of the study. Storage and distribution of the product to the study participants in the responsibility of the principle investigator. Medical preparations will be carried out through the institution pharmacy, unless the ethics committee states otherwise.
K. Preparations of medical supplies listed in Israel must be made in the institutional pharmacy.

Regulation: Recruitment for Medical Research in Humans	Date
Forms	

Form 7 – Page 3 of 3
Administrative Approval Helsinki Committee for Medical Research on Humans The effect of 28 days of beta-alanine ingestion on military performance (physical and cognitive) in a Special Forces unit. IDF-1267-2013

1. Document storage: Keep all application documents. Approvals and all documents collected during the clinical trial must be stored for at least 15 years after the study.
2. Other limitations:
3. This approval is valid for:

Good Luck

Brigadier General Professor Yitzhak Kreiss
Surgeon General Israel Defense Force

Cc: Chairmen of Helsinki Committee
Administrator of the IDF Pharmacy
Head of the Research branch of the IDF

ISRAEL IRB APPROVAL

שם הנוהל: נוהל לניסויים רפואיים בבני-אדם	תאריך: ינואר 2006
טפסים	

טופס 7 - עמוד 1מתוך 2

אישור מנהל המוסד הרפואי לביצוע ניסוי רפואי בבני-אדם

effect of 28 days of beta-alanine Supplementation on tactical performance and cognitive function in elite special operation soldiers

IDF-1267-2013

תאריך: 26 6 13

לכבוד:

ד"ר ישי אוסטפלד-חוקר ראשי

מפקדת העומק/אג"ם/רפואה

פרופ'/ד"ר נכבד/ה,

הנדון: **אישור לביצוע ניסוי רפואי בבני-אדם**

בהתאם לבקשתך מיום: 22.06.2013 ניתן בזה אישור מספר:IDF-1267-2013 , לביצוע הניסוי הרפואי לפי פרוטוקול הניסוי שצורף לבקשה.

מספר הבקשה בוועדת הלסינקי: IDF-1267-2013	מספר הבקשה במשרד הבריאות:אין	מספר הרישום באתר ה-NIH:
נושא הניסוי הרפואי: effect of 28 days of beta-alanine Supplementation on tactical performance and cognitive function in elite special operation soldiers		
ניסוי רב-מרכזי בארץ: פטור		ניסוי רב-מרכזי בארץ: פטור
מספר הפרוטוקול: 1267-2013	גרסה: 2.0	תאריך: 22.06.2013
טופס הסכמה: גרסה: 2.0		תאריך: 22.06.2013
חוברת לחוקר (אם יש): גרסה:ל"ר		תאריך: --
שם החוקר הראשי: ד"ר ישי אוסטפלד		מחלקה: מפקדת העומק/אג"ם/רפואה
שם היוזם וכתובתו: ד"ר ישי אוסטפלד		שם נציגו בארץ וכתובתו: מפקדת העומק/אג"ם/רפואה

בתוקף ההסמכה שקיבלתי מהמנהל הכללי של משרד הבריאות, לתת אישור כ"מנהל" לעשיית ניוי רפואי בבני-אדם, בחיל הרפואה, לאחר שהבקשה אושרה על-ידי ועדת הלסינקי המוסדית בתאריך 22/06/2013 ולאחר ששוכנעתי כי הניסוי הרפואי הנו בהתאם לעקרונות של הצהרת הלסינקי ותקנות בריאות העם (ניסויים רפואיים בבני-אדם) תשמ"א-1980, וכי חוזה ההתקשרות בין היוזם, החוקר הראשי והמוסד הרפואי עומד בדרישות הנוהל לניסויים רפואיים בבני אדם, הנני מאשר את ביצוע הניסוי בכפוף לתנאים הבאים:

טופס 7 - עמוד 2מתוך 2

אישור מנהל המוסד הרפואי לביצוע ניסוי רפואי בבני-אדם

effect of 28 days of beta-alanine Supplementation on tactical performance and cognitive function in elite special operation soldiers

IDF-1267-2013

תאריך: 26.6.17

<u>תנאי האישור:</u>

1) הניסוי הרפואי יבוצע לפי העקרונות של הצהרת הלסינקי ועל-פי דרישות הנוהל של ניסויים רפואיים בבני אדם בישראל (2005) ודרישות הנהלים הבין-לאומיים העדכניים.

2) הטיפול יינתן רק לאחר מתן הסבר למטופל/ת או לנציגו/ה החוקי והחתמתו/ה על טופס ההסכמה מדעת שצורף לבקשה.

3) כל שינוי, תוספת או סטייה מפרוטוקול הניסוי הרפואי, טעון אישור בכתב של ועדת הלסינקי של המוסד הרפואי ו/או של משרד הבריאות.

4) על החוקר הראשי בניסוי הרפואי לדווח לוועדת הלסינקי של המוסד הרפואי וליוזם על כל אירוע חריג רציני (SAE) שארע במהלך הניסוי הרפואי (כמפורט בסעיף 15.1.1 בנוהל), או על הפסקת הניסוי. ועדת הלסינקי המוסדית תבדוק את הדיווח ותעביר את חוות-דעתה למשרד הבריאות.

5) הארכת תוקף הניסוי הרפואי: **חודשיים בטרם חלוף התקופה המאושרת לניסוי הרפואי**, חובה על החוקר הראשי להעביר דו"ח התקדמות על מהלך הניסוי לוועדת הלסינקי של המוסד הרפואי. הוועדה תודיע על החלטתה לגבי המשך הניסוי למנהל המוסד הרפואי. המנהל ינפיק אישור חדש לניסוי הרפואי.

6) בתום הניסוי הרפואי יגיש החוקר הראשי, לוועדת הלסינקי דו"ח מסכם על מהלך הניסוי ותוצאותיו.

7) האישור ניתן לחוקר הראשי ולמוסד הרפואי המצוינים לעיל ואינו ניתן להעברה לאחר.

8) בניסויים רפואיים הכרוכים במתן שירותים: ביצוע בדיקות רפואיות או באספקת אביזרים, תכשירים רפואיים או משתלים, חובה על החוקר הראשי להודיע לרופא המטפל בחולה בקהילה על השתתפותו בניסוי.

9) אין לפרסם כל מידע אודות הניסוי הרפואי באמצעי התקשורת ההמוניים, כגון עיתונות, רדיו, טלוויזיה, אינטרנט, למעט פרסום בעיתונות מדעית או בכנסים מדעיים, ולמעט פרסום לצורך גיוס המשתתפים בניסוי.

10) אספקת מוצר המחקר (**Investigational Product – IP**) או האמ"ר למוסד הרפואי בו נערך הניסוי הרפואי היא באחריות יוזם הניסוי. אחסונו וניפוקו של מוצר המחקר למטופלים הם באחריות החוקר הראשי. במקרים של תכשירים רפואיים, פעולות אלו יבוצעו באמצעות בית המרקחת המוסדי, אלא אם כן ועדת הלסינקי החליטה אחרת.

11) אספקת תכשירים רפואיים הרשומים בישראל תעשה באמצעות בית-המרקחת המוסדי.

12) שמירת מסמכים: יש לשמור את כל מסמכי הבקשה, האישורים וכל המסמכים הנאספים במהלך הניסוי הרפואי **לפחות 15 שנים מתום הניסוי**.

13) הגבלות נוספות: ____________________

14) תוקף האישור: 26.6.14

בהצלחה!

בכבוד רב,
תא"ל פרופ' יצחק קרייס
קצין הרפואה הראשי

ק/ 3777251
תא"ל פרופ' יצחק קרייס
קצין הרפואה הראשי

העתק: יו"ר ועדת הלסינקי המוסדית: <u>אל"מ ד"ר דודו דגן</u>
מנהל/ת בית המרקחת של המוסד הרפואי: ____________
היוזם/נציגו בארץ (באמצעות החוקר): ____________
ר' תחום מחקר: <u>רס"ן ד"ר גדי אבבה קמפינו</u>

APPENDIX D: INFORMED CONSENT

ISRAEL INFORMED CONSENT TRANSLATION

The Effect of 28 day beta-alanine ingestion on military performance (physical and cognitive) in a special forces unit. March 24, 2013

Regulation: Recruitment for Medical Research in Humans	Date
Forms	

Form 2a – Military Version – Page 1 of 3
Informed Consent Agreement for Medical Experiment in Humans

Request number from Helsinki Committee (To be filled out by Committee Secretary):

<u>I that is signed underneath</u>

Name: First and Last: Rank: Unit:
Identification number: Military Identification number
Address Zip Code

L. I declare that I agree to participate in the medical study, as detailed in this document.
M. I declare that I am not involved in another clinical trial involving the use of any product, and I pledge not to participate in a clinical trial another research product for the duration of this experiment.
N. I declare in this document that I have been explained this information by:

Name of the Investigator providing the Consent:

4. The principle investigator, Dr XXXXX received from the medical institution where the experiment was conducted, Surgeon General of the Israel Defense Force is required to provide permission to conduct clinical research on humans, and to determine the significance that the clinical has on improving the health of the nation (clinical studies in humans). This requirement has been since 1980.
5. The principle investigator initiated the study.
6. The physician responsible for medical oversight is Dr. XXXXX.
7. The clinical study is on the following topic:

8. I understand that I am free to choose to participate or not to participate in this clinical study, and I am free to stop by participation at any time of the study, without any prejudice to my rights to receive the usual treatments.

6. I understand that if I refuse to participate or discontinue my participation I will not be subject to any punishment by the military, or will I be in violation of any right relating to my military services, and if I agree to participate in the study it will not provide me any additional benefit.
7. I understand that I do not have to completely fill out any document or cannot decide to only participate in some of the assessments.
8. I understand that my personal identity, including information regarding my service in my unit will not be published in any scientific publication.
9. I understand that the Ministry of Defense or the Israel Military will financially be responsible for the budget of the investigators that are participating in the clinical study. Third-party claims associated with the clinical trial during the execution of the study or subsequently following the study will not be less in scope and will be in terms of the insurance coverage provided by a medical institution with the laws of the State of Israel. The foregoing does not prejudice my rights under the law.
10. I understand that with regard to the dietary supplement beta-alanine, the approval for its use is from the Helsinki committee of the Medical Corps and its use is subject to their monitoring program.
11. I have been assured that all answers to my questions have been answered and that I have the ability to consult with other factors (e.g. Unit's physician, another doctor, family, etc.) as to aid in my decision to participate in this clinical study.
12. If I have any problem with the clinical trial, I can contact Dr. XXXXX (XXX-XXX-XXXX) around at any time.

D. I hereby declare in that said, the detailed information about the clinical trial is in accordance with the following topics:

1. The goals of the study are to examine the physical and cognitive effects of beta-alanine.
2. The number of participants that will be recruited for this study are 20.
3. The expected duration of the study that I will be participating in is 28 days.
4. Methods:
   - Use the supplement beta-alanine for 28 days (take two pills, three times per day for a total of six grams of beta-alanine a day).
   - Participants will be required to perform physical assessments, shooting, complete questionnaires and have a MRI performed on the head and legs at the beginning and end of the study.
   - The study is a placebo (rice powder) controlled, double blind protocol, meaning that neither the participant nor the investigators will know what they are taking until the study is concluded.
   - During the course of the study my regular activity (both in the unit and outside of the unit) will be performed without any differences. I understand that I will not be allowed to take any additional supplement or food that can improve performance.

Form 2a – Military Version – Page 2 of 3
Informed Consent Agreement for Medical Experiment in Humans

5. At the end of the study, if I so choose, I will be able to receive the study results and find out whether I was in the beta-alanine or placebo group. I will also be able to understand whether the supplement provided benefits to those participants that ingested beta-alanine.
6. Possible Study benefits;
   If the study points to the beneficial impact that the supplement beta-alanine has on performance (either physical or cognitive) of combatants, similar to competitive athletes, it will be possible to recommend widespread use of this dietary supplement to various IDF units in order to improve performance.
7. Known risks and or discomforts for participants during the study;
   - Paresthesia (feeling of skin tingling)
   - There may be some discomfort due to prolonged lying (for half an hour) at the time of MRI testing.
   - The usual dangers associated with military and physical activity that is common to the unit.
8. Circumstances in which participation in the clinical trial may be stopped by the decision of the investigator;
   In case of non-compliance with the experiment (e.g., stop ingestion of beta-alanine or start using other dietary supplements, the appearance of disease – even if it is not related to the use of beta-alanine).
9. Other relevant information (as provided by the investigator):
   In addition to this consent form I received another form from the investigator with a detailed explanation of the experiment.

E) I hereby declare that the above consent is freely given and that I understood all of the above. In addition, I received a copy of this informed consent form, is dated and duly signed.
Signature of participant:

First name	Family Name	Rank	ID#	Military ID#	Unit	Date	Signature

F) I hereby declare the said agreement was accepted by the participant after I explained the expectations of the clinical trial and made sure that he understood all what was expected.
Signature of the investigator:

First name	Family Name	ID#	Date	Signature

ISRAEL INFORMED CONSENT APPROVAL

שם הנוהל: **נוהל לניסויים רפואיים בבני-אדם**	**תאריך: ינואר 2006**
טפסים	

טופס 2 א' - גירסה צבאית - עמוד 1 מתוך 3
טופס הסכמה מדעת להשתתפות בניסוי רפואי בבני אדם

מספר הבקשה בוועדת הלסינקי (למילוי על ידי מזכירות הוועדה):

<u>אני החתום מטה</u>

שם פרטי ומשפחה: דרגה: יחידה:
מספר תעודת זהות: מספר אישי:
כתובת: מיקוד:

א) מצהיר בזה כי אני מסכים להשתתף בניסוי רפואי, כמפורט במסמך זה.

ב) מצהיר בזה כי איני משתתף בזמן חתימת מסמך זה, בניסוי רפואי אחר הכרוך בשימוש במוצר מחקר כלשהו, וכי אני מתחייב לא להשתתף בכל ניסוי רפואי אחר הכרוך בשימוש במוצר מחקר במשך כל תקופת ניסוי זה.

ג) מצהיר/ה בזה כי הוסבר לי על-ידי:

שם החוקר המסביר:

1. כי החוקר הראשי: <u>ד"ר ג'יי הופמן</u> קיבל ממנהל המוסד הרפואי בו נערך הניסוי, קצין רפואה ראשי של צה"ל, אישור לביצוע הניסוי הרפואי בבני-אדם, כמשמעותו בתקנות בריאות העם (ניסויים רפואיים בבני-

אדם) תשמ"א-1980 (להלן הניסוי הרפואי).

2. כי החוקר הראשי הוא יוזם הניסוי.

3. כי הרופא האחראי לניסוי הוא: ד"ר ישי אוסטפלד.

4. כי הניסוי הרפואי נערך בנושא:

ההשפעה של מתן תוסף התזונה בטא-אלנין במשך 28 ימים על התפקוד המבצעי (גופני וקוגנטיבי) של לוחמי קבע ביחידה מיוחדת.

5. כי אני חופשי לבחור שלא להשתתף בניסוי הרפואי וכי אני חופשי להפסיק בכל עת את השתתפותי בניסוי, כל זאת מבלי לפגוע בזכותי לקבל את הטיפול המקובל.

6. כי סרובי להשתתף המחקר לא יגרור ענישה או הרעה בתנאי שרותי הצבאי, או פגיעה בזכות כל שהיא הקשורה לשרותי הצבאי וכי הסכמתי להשתתף במחקר לא תקנה לי כל זכות או הטבה שאינה נובעת מעצם השתתפותי במחקר.

7. כי בעת מילוי השאלון - אני רשאי שלא לענות על כל השאלות שבשאלון או על חלק מהן.

8. כי מובטח לי שזהותי האישית ובכלל זאת שירותי ביחידה בה אני משרת, ישמרו בסודיות על-ידי כל העוסקים והמעורבים במחקר ולא יפורסמו בכל פרסום, כולל בפרסומים מדעיים.

9. כי משרד הביטחון או צה"ל פעלו להסדרת כיסוי תקציבי הולם מתקציב משרד הביטחון של החוקרים, הרופאים והצוות הרפואי העוסקים בניסוי הקליני מפני תביעות שיוגשו ע"י משתתפים בניסוי הקליני ו/או תביעות צד ג' הקשורות עם הניסוי הקליני בין בתקופת ביצוע הניסוי ובין לאחריו. הכיסוי לא יפחת בהיקפו ובתנאיו מהכיסוי הביטוחי הניתן על ידי מוסד רפואי בהתאם לדיני מדינת ישראל. אין באמור כדי לפגוע בזכויותיי על פי כל דין.

10. כי ההחלטה לגבי מתן תוסף התזונה בטא-אלנין נתונה בידי ועדת ההלסינקי של חיל הרפואה והכל כפוף לקיום תכנית שימוש ומעקב.

11. כי מובטחת לי נכונות לענות לשאלות שיועלו על-ידי וכן האפשרות להיוועץ בגורם נוסף (לדוגמא רופא-היחידה, רופא אחר, בני משפחה וכו'), באשר לקבלת החלטה להשתתף בניסוי הרפואי ו/או להמשיך בו.

12. כי בכל בעיה הקשורה לניסוי הרפואי אוכל לפנות לד"ר ישי אוסטפלד במספר טלפון: 052-9242938, בכל שעות היממה.

ד) הנני מצהיר/ה כי נמסר/ה לי מידע מפורט על הניסוי הרפואי, על פי הנושאים המפורטים להלן:

1. מטרות הניסוי; בדיקת ההשפעה הגופנית והקוגנטיבית של שימוש בתוסף התזונה בטא אלנין
2. המספר בקירוב של המשתתפים בניסוי הרפואי; כ- 20
3. התקופה הצפויה למשך ההשתתפות בניסוי; 28 יום
4. שיטות;

- שימוש בתוסף התזונה בטא-אלנין במשך 28 ימים (נטילת שתי גלולות, שלוש פעמים ביום, סך הכול 6 גרם של בטא-אלנין ליום)
- ביצוע בוחן כשר גופני, מטווח, מילוי שאלונים וביצוע בדיקת MRI (לראש ולגפיים) - בתחילת הניסוי ובסופו
- הניסוי הוא מסוג "כפול סמיות". על כן, כלל המשתתפים יחולקו באופן אקרעי לשתי קבוצות. קבוצה אחת תקבל את תוסף התזונה בטא אלנין והשניה תקבל אינבו ("פלצבו"), המכיל סוכר, ללא חומר פעיל ותשמש כ"קבוצת ביקורת". בחירתי לאחת משתי הקבוצות תעשה בצורה אקרעית, ללא ידיעתי וללא ידיעת החוקרים
- במהלך תקופת הניסוי אמשיך בפעילותי הרגילה (ביחידה ומחוץ ליחידה), ללא כל הבדל אולם לא אשתמש בשום תוסף מזון או "משפר ביצועים" (מלבד הבטא אלנין)

5. בסיום הניסוי, אם ארצה בכך, יפרטו בפני החוקרים את תוצאות מבדקי השונים ויגלו האם נכללתי בקבוצה שהשתמשה בבטא אלנין או בקבוצת ה"אינבו".
6. יתרונות הצפויים למשתתף או לאחרים, כתוצאה מהניסוי;

במידה והמחקר יצביע על השפעה מטיבה של השימוש בתוסף התזונה בטא-אלנין על תפקוד (גופני או קוגנטיבי) של לוחמים, בדומה לשיפור המתואר בספורטאים, ניתן יהיה להמליץ על שימוש נרחב בתוסף ביחידות צה"ל השונות, על מנת לשפר את ביצועי הלוחמים בקרב

7. הסיכונים הידועים ו/או אי-הנוחות שניתן לחזותם למשתתף במחקר;

- עקצוץ עורי חולף, בשל נטילת הבטא אלנין
- תיתכן אי נוחות מסויימת בשל השכיבה הממושכת (במשך כחצי שעה) בעת ביצוע בדיקת ה-MRI
- הסכנות הרגילות ביחידה, עקב פעילות גופני ומטווחים

8. נסיבות בהן עלולה השתתפותי בניסוי הרפואי להיפסק, בהחלטת החוקר או היוזם;

בכל מקרה של אי עמידה בתנאי הניסוי (למשל, הפסקת השימוש בבטא-אלנין או התחלת שימוש בתוסף מזון אחר, הופעת מחלה, אף אם אינה קשורה לשימוש בבטא-אלנין)

9. מידע רלוונטי אחר (כפי שנמסר על-ידי יוזם הניסוי):

הסבר מפורט אודות הניסוי בנוסף לטופס הסכמה זה קיבלתי טופס נוסף מאת החוקר הראשי ובו

ה) הנני מצהיר בזה כי את הסכמתי הנ"ל נתתי מרצוני החופשי וכי הבינותי את כל האמור לעיל. כמו-כן, קיבלתי עותק של טופס הסכמה מדעת זה, נושא תאריך וחתום כדין.

חתימת הנבדק:

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שם פרטי שם משפחה דרגה מספר תעודת זהות מספר אישי יחידה תאריך חתימה

ו) הנני מצהיר בזה ההסכמה הנ"ל נתקבלה על-ידי וזאת לאחר שהסברתי למשתתף בניסוי הרפואי כל האמור לעיל וכן וידאתי שכל הסבריי הובנו על-ידו.

חתימת החוקר המסביר:

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שם פרטי שם משפחה מספר תעודת זהות תאריך חתימה

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