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Physical and Performance Characteristics May Influence Successful Completion of Military Tasks on the Sandhurst Competition

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Physical and Performance Characteristics May Influence Successful Performance on Military Tasks of the Sandhurst Competition

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ABSTRACT

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Identification and development of physical characteristics that lead to efficient performance of military skills or tasks has been a consistently difficult task for the United States military for decades. The literature suggests certain physical characteristics may be more important, although this information is conflicting. Furthermore, the military physical fitness training program that is intended to prepare soldiers for combat is commonly evaluated with the Army Physical Fitness Test (PFT), a test that is more suited for evaluating health and wellness rather than task-specific fitness. All of this testing and training of soldiers focuses on the individual soldiers and their abilities although military skills or tasks are seldom if ever conducted independently. The first purpose of this dissertation was to identify relationships between the PFT, anthropometrics, measures of strength, and power. The second purpose was to identify the team characteristics that influence team performance during the Sandhurst Competition (a 2-day simulated military operation). Strong correlations were found between PFT events and weak correlations were found between PFT measures and evaluations of strength and power. The strong correlations between PFT events could indicate that only one event may be necessary to determine health and wellness. The weak correlations between events of the PFT and measures of strength and power suggest the PFT is not an assessment of strength and power based on the strength and power measures employed in the current study. The evaluation of team characteristics indicated that age

(possibly experience) had the largest effect on Sandhurst Competition performance. Further analysis of each event supported the contention that age influences performance but also identified specific aerobic, anaerobic, and anthropometric variables that influenced performance on particular events. The data from this dissertation suggests that teams competing in the Sandhurst Competition should attempt to recruit team members with more experience, very high run scores, and high vertical jump heights.

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CHAPTER 1

INTRODUCTION

Physical Tasks of Military Operation

For decades the Army has been conducting physical fitness for the preparation of their soldiers to effectively handle the tasks associated with combat. Over the years combat tasks have been identified by several researchers. In their assessment combat tasks include lifting, pushing, pulling, throwing, carrying heavy loads for short distances (Forman, 1997) jumping, landing, running, marching (Batchelor, 2008), climbing, and crawling (Department of the Army, 2011). The majority of the tasks are related to one's ability to produce force or strength (Batchelor, 2008; Knapik, Rieger, Palkoska, Camp, & Darakjy, 2009). Some researchers have noted that strength is more important than endurance in current combat activities (Batchelor, 2008; Forman, 1997; Knapik et al., 2009). Physiological attributes involved in military operations typically involve strength-power activities coupled with high intensity intervals (Knapik, 1989).

The Army is an encompassment of hundreds of different jobs that are all important to ensure mission success. If there is a decrement in one of these areas, probability of mission success begins to decline. In the 1992 edition of Field Manual 21-20 it states that soldiers need speed, agility, muscle power, and hand-foot-eye coordination because these factors affect a soldier's survivability on the battle field (Department of the Army, 1992). At the time of this publication, those were characteristics the Army felt were necessary for soldier survivability and mission success. In the most recent edition of Physical Readiness Training manual, the Army identifies that assaulting a location, running and crawling long distances, jumping in and out of craters and trenches, jump over obstacles, and to lift and carry heavy objects (Department of the Army, 2011) are all involved in military activities.

Intuitively, improving these characteristics would seemingly improve soldier survivability and mission success. In the new physical fitness training manual TC 3-21.20 there is no identification of how the ability to perform these military tasks were determined as components of a successful soldier. Although military professionals have examined military activities, other researchers have identified slightly different activities.

Researchers have been examining tasks associated with military operations for several years. In 1997 Forman described lifting, pushing, pulling, throwing, and carrying heavy loads for short distances as physical tasks associated with soldiering (Forman, 1997). Batchelor (2008) administered a survey to infantry officers of many different units asking them to identify the six most important tasks of soldiering out of 22 that were listed. There were over 600 responses that identified lifting from the ground, lifting overhead, pushing, jumping and landing, marching, and running (Batchelor, 2008).

The Army's identified tasks and research identified tasks seem to be quite similar in nature. Based on this assessment it is unclear how the Army Physical Fitness Test (APFT) relates to operational tasks.

Current Army Physical Fitness Tests

The APFT is a battery of three tests; 2 minutes of push-ups, 2 minutes of sit-ups, and a 2-mile run (Department of the Army, 1992, 2011). These events have been the standard for assessing a unit's fitness since the 1985 publication of the FM 21-20 (Department of the Army, 1992). Researches have attempted to identify the physical characteristics associated with successful performance on each of these events. The determination of the push-up and sit-up tests as strength or muscular endurance may be difficult to identify because muscular strength may affect muscular endurance. Muscular strength and absolute muscular endurance are closely related for the push-up task (r= 0.74) (Knapik, 1989). Therefore, it is suggested that for military purposes muscular strength and muscular endurance do not need to be assessed separately (Knapik, 1989). The push-up and sit-ups test is at best adequate at assessing muscular strength and endurance for the male population (Knapik, 1989). Although it may be adequate for assessing male muscular strength and endurance, it was determined that push-ups were not a viable method among females because of a lack of research (Knapik, 1989). Knapik (1989) concluded that the 2-mile run was a valid measure of aerobic fitness for both males and females because it correlated well with VO_2 max testing. This seems to provide adequate evidence that the APFT is overall a good way to assess aerobic capacity and muscular strength and endurance.

The Department of the Army and researches seem to be in agreement that the APFT assesses muscular endurance and aerobic capacity (Department of the Army, 1992, 2011; Knapik, 1989). The physical fitness test has received some scrutiny because it has been suggested that it does not test appropriate aspects of combat. This is further illustrated through the following statements. “The APFT is a general fitness test, not a combat fitness test” (Forman, 1997). The APFT is the primary instrument for evaluating the fitness level of each soldier (Department of the Army, 1992). In the newest version of the Army training manual (TC 3-22.20), it states that the APFT is to “provide an assessment of the Physical Readiness Training (PRT) program and is designed to ensure the maintenance of a base level of physical fitness essential for every soldier” (Department of the Army, 2011). If essential physical fitness deals with combat activities, then the APFT is deficient in the ability to assess combat tasks that are commonly strength and power dependent. The APFT is a measure of upper and lower body muscular endurance; a soldier’s ability to handle his or her own body weight (Department of the

Army, 2011) and an assessment of aerobic power (Knapik, 1989). The physical fitness test is lacking an assessment of strength which, as addressed earlier may, be a large factor in military operations.

Batchelor (2008) assessed the applicability of the APFT to the contemporary operating environment. Batchelor identified through exercise explorer software that the push-up and sit-up test are measures of upper body muscular endurance and the 2-mile run is a measure of lower body muscular endurance and aerobic power. Bachelor (2008) emphatically states that the APFT is a measure of "general fitness" not combat fitness. Thus, the APFT may need to be "redesigned" to adequately assess combat fitness.

Physical Characteristics Needed for the Army Physical Fitness Test

The APFT is designed to test a soldier's level of physical fitness (Batchelor, 2008; Department of the Army, 1992; Knapik, 1993) as it pertains to health. It has been established by the military that the APFT is a good indicator of aerobic capacity and muscular strength and endurance (Department of the Army, 1992; Knapik, 1989). The most recent copy the Army physical fitness training manual changed the focus of what the APFT is testing with the push-ups and sit-ups, these tests no longer assess muscular strength, only muscular endurance (Department of the Army, 2011).

VO_2 max is a test that assesses an individual's ability to maximally use oxygen to produce energy. Individuals with a higher VO_2 max have been shown to perform better on the Coopers 12-min run test (Rosendal, Langberg, Skov-Jensen, & Kjaer, 2003; Santtila, Keijo, Laura, & Heikki, 2008), 3000 m run (Grant, Craig, Wilson, & Aitchison, 1997) 2-mile run (Crawford et al., 2011; Knapik et al., 2006) or on endurance running performance in general

(Denadai, Ortiz, Greco, & Mello, 2006). This research suggests that success on the APFT is dependent on muscular endurance and aerobic power (VO_2 max). Therefore, based on the APFT as the test to assess performance, increasing a soldier's muscular endurance and VO_2 max should increase the score on the APFT and performance of military operational tasks.

Body Composition

Body composition in the military has been tested for decades. The methods by which body composition has been assessed have changed over the years (Marriott & Grumstrup-Scott, 1992). Currently, the body fat assessment uses the girth measurements of neck and waist. This may not be an ideal way to determine body composition because fat mass has been reported to be less important than lean mass. Marriott and Grumstrup-Scott proposed that examining lean muscle mass should be a criterion for acceptance into the military. Forman later added to this idea by stating that the minimum amount of lean muscle mass that is acceptable for Army soldiers is 50 kg (Forman, 1997). This is on the basis that having a lean muscle mass of 50 kg allows the soldiers to be able to lift about 100 lbs. This may be a misrepresentation of an appropriate amount of lean muscle mass. The average soldier weights 165 lbs. (Forman, 1997; Marriott & Grumstrup-Scott, 1992); therefore, to carry a fellow soldier off the battle field it would be expected that all soldiers have a minimum lean muscle mass that will allow them to lift 165 lbs. This standard of lean muscle mass has been proposed by Marriott and Grumstrup-Scott, to be the more appropriate standard for military members. This information corroborates the previously stated research that completion of many military tasks is dependent upon strength.

Physical Characteristics of Operational Task Analysis

As previously stated, there are a certain set of tasks that are key to mission success and potentially increase soldier survivability. To reiterate, these tasks are lifting from ground, pushing, pulling, jumping and landing, carrying heavy loads, running, and marching. In 2008 Batchelor did a comparative analysis of the APFT to soldiering tasks identified by FM 21-20 to determine if military tasks are strength, strength and endurance, or endurance based activities. Through the use of Exercise Explorer software, the movements of lifting from ground, lifting overhead, pushing, jumping and landing, lunging (assaulting or fire team rush), marching, and running were broken down by muscle action (Batchelor, 2008). The performance characteristics for each of these tasks were identified and classified as a strength, strength and endurance, or endurance task. The task analysis revealed that of lifting from the ground, lifting overhead, pushing, and jumping and landing are all strength based activities. The tasks of lunging and running (sprinting) are listed as strength and endurance. Last, marching was listed as an endurance task (Batchelor, 2008). However, the literature has shown that stronger soldiers can move faster and with more weight than weaker soldiers, which would carry over to a variety of military tasks (Marriott & Grumstrup-Scott, 1992).

In the second article of a three-part study by Rayson, Holliman, and Belyavin, (2000), they identified relationships between critical tasks (single lift to 1.45 and 1.7 m, carry task, repetitive lift and carry with 10, 22, and 44 kg, and 12.8 km loaded foot marches at 15, 20, and 25 kg) for all British soldiers and anthropometric and performance characteristics. The single lift to 1.45 and 1.7 m were statistically positively correlated to fat free mass ($p < 0.001$) (Rayson et al., 2000). The carry task was statistically positively correlated to dynamic arm flexion and pull-ups ($p < 0.001$) (Rayson et al., 2000). The repetitive lift and carry task was statistically positively correlated to lift power (44 kg), dynamic arm flexion endurance (22 kg), and 38 cm upright pull (10 kg). All lift and carry tasks correlations were statistically positively correlated at $p<0.001$ (Rayson et al., 2000). The loaded foot march was statistically negatively correlated to body mass (25 kg load) and multistage fitness test (all loads) at $p< 0.001$ (Rayson et al., 2000).

This suggests that the individual strength and repeated sprinting ability (multistage fitness test) of the soldier may affect the ability to perform tasks specific to soldering. Furthermore, research suggests that aerobic power and endurance are not as important to modern military tasks in comparison to strength (Knapik et al., 2009).

On the contrary, a comprehensive analysis of Navy SEAL fitness components and their perceived influence on mission success may suggest something different. Prusaczyk, Stuster, Goforth Jr, Smith, and Meyer (1995) surveyed 82 Navy SEALs on 15 missions to evaluate physical characteristics that SEALs perceive to have the greatest impact on mission success. Evaluation of general abilities showed stamina (endurance) to be second most important behind team work where strength was listed as sixth most important (Prusaczyk et al., 1995). Further analysis of percent of mission segments revealed that aerobic endurance of lower limbs is a primary fitness component and was suggested to be 93 % of mission segments. Secondary fitness components were specifically identified by different segmental strength abilities (lower limbs, neck and back, arm and shoulder, etc.). Strength of the lower limbs (93 %), neck and back (67 %), and arm and shoulder (67 %) showed highest percent of mission segment as secondary components.

This provides some support that aerobic fitness may be more important in Navy SEAL operations. The disparity between the research may be a result of specific tasks, meaning average soldiers may need greater emphasis on strength development because of tasks expected to be performed. Navy SEALs may have tasks that require a greater emphasis on endurance due to the nature of their missions, moving to and from target without being noticed. This suggests that SEALs and average soldiers may need different physical fitness characteristics to be successful. However, it is unclear as to whether the perceptions of the SEALS reflected an adequate understanding of the relationship of strength (and related characteristics such as power) to endurance activities. So, while the perception of effort indicated that tasks were endurance based, the SEALS did not realize the underlying contribution of maximum strength to these tasks.

Physical Characteristic of Successful Combat Sport Athletes

It is understood that upon accepting the position as a soldier, every individual is joining an organization that is in the business of keeping peace. This quite often entails combat operations in a hostile environment. To get a better understanding of the physical characteristics that make combat sport athletes successful an analysis of taekwondo, kung fu, wrestling, and judo were performed. The physical characteristics that set successful and less successful combat sport athletes apart should be, in part, similar to the characteristics that make successful soldiers.

Taekwondo

The sport of taekwondo is a relatively new sport discipline that is considered to be highly demanding of most muscle groups (Marković, Misigoj-Duraković, & Trninić, 2005). This study was an examination of specific fitness profiles of taekwondo athletes who have won medals at European Championships, World Championships, or Olympic Games compared to athletes who have not won a medal at these competitions. Anthropometrics, physiological characteristics, and bio-motor abilities were assessed over a 3-day period. Their results showed no statistically significant differences in anthropometric measurements. Medal winning athletes were significant better in maximal running speed, counter movement jump, and 20 m sprint speed. There were no significant differences in bench press or back squat between medal winner and those who have not won medals, although medal winners' bench pressed 7 kg more and squatted 17 kg more than nonmedal winners. The effect size for bench press was Cohen's d=0.73 and back squat Cohen's d=1.04 (Marković et al., 2005). This demonstrates that successful taekwondo athletes have a significantly greater power output and greater strength than less successful taekwondo athletes. Interestingly enough, 60-sec push-ups, 60-sec sit-ups, and VO_2 max did not differ statistically between successful and less successful taekwondo athletes. Long distance running (VO_2 max) and muscle endurance were not discerning factors in the combat sport of taekwondo (Marković et al., 2005).

Kung Fu

Kung Fu was recently introduced into the Olympic Games as Wushu. This is a form of Kung Fu that standardizes the rules for competition (Artioli et al., 2009). This form of Kung Fu is characterized by both grappling and striking techniques, which separates it from other types of combat sports that are only grappling (wrestling) or striking (taekwondo). The article by Artioli et al. (2009) identified different physical characteristics that 14 Olympic Wushu athletes possessed. The barrage of tests included anthropometric measurements, anaerobic arm power (cycle ergometer), vertical jump, lumbar isometric strength (lumbar extension dynamometer), flexibility, and lactate measures (after the anaerobic arm power test) (Artioli et al., 2009). Their results showed that Olympic Wushu athletes have low body fat, high flexibility, high leg power, and moderate arm anaerobic power. Artioli et al. (2009) states that even though Olympic Wushu is a mix of grappling and striking techniques, it requires similar characteristics of other combat sports.

Wrestling

Wrestling is another Olympic sport that has definitive characteristics that allow for success in this sport. (Yoon, 2002) did a review of the literature on the physiological profiles of elite senior wrestlers. In this review physique and body composition, anaerobic characteristics, and aerobic characteristics were evaluated in their effect on wrestling success. Body composition and physique are an important part of wrestling because of weight classes. Wrestler with lower body fat tend to carry increased amounts of lean muscle mass, which in turn affects the maximum strength of a wrestler and potentially increases the chance of success. Yoon (2002) stated that wrestlers should establish a steady-state fat percentage of 7%-10 %. Analysis of anaerobic characteristics indicates that absolute strength is greatest in heavier wrestlers, but relatively, per kg, lighter wrestlers are stronger. Yoon stated that greater strength appears to be advantageous. Wrestlers need to have a high power output because it is associated with quick explosive maneuvers that lead to the control of the opponent (Yoon, 2002). Anaerobic power may be a differentiating factor when examining junior elite wrestlers compared to nonelite wrestler. Anaerobic power was 13 % greater in junior elite wrestlers of similar weight and experience than that of nonelite wrestlers (Yoon, 2002).

Judo

The next review sheds light on the physical characteristics important to the sport of Judo. Although very similar to the combat sports listed previously, judo is characterized by throws, or takedowns, but also includes chokes and joint locking, similar to grappling. It is important to identify that the success of judo competitors depends upon sound technique applied at an opportune time with strength, velocity, and power (Franchini, Del Vecchio, Matsushigue, & Artioli, 2011). In a very similar fashion to wrestlers, judo athletes try to maximize lean body tissue and minimize body fat. In summary, high level judo athletes present highly developed dynamic strength, muscle endurance, anaerobic power and capacity, and aerobic power and capacity (Franchini et al., 2011). Aerobic power and anaerobic power are considered important although data showed no statistically significant differences among judo athletes of varying levels.

In summary of combat athletes, strength, anaerobic power and capacity, and low body fat percent are among the major contributors of more successful combat sport athletes. Therefore, assuming that many military tasks are similar to combat sports (Artioli et al., 2009) then logically the military should focus on these characteristics to improve performance. It was also identified that VO_2 max (Yoon, 2002), push-ups, and sit-ups (Marković et al., 2005) were not among the factors that separate successful and less successful combat sport athletes. This evidence suggests that the APFT measures may not be appropriate or sensitive enough for the evaluation of mission readiness for soldiers.

Physiological Characteristics of Effective Load Bearing

Historians have previously reported that heavy load carriage has directly or indirectly caused poor performance, unnecessary death, and lost battles (Knapik, 2000). Combat loads have continued to increase throughout history as the battlefield and weaponry have changed (Dziados, 1987; Knapik, 2000). In operation Desert Shield it was estimated that the average combat load was over 40 kg (Knapik, 2000) and researchers have assessed performance up to 46 kg (Knapik et al., 1990). Researchers have shown that there are specific physical characteristics that lead to greater load bearing capacity. VO_2 max (Dziados, 1987; Harman et al., 2008; Knapik et al., 1990; Kraemer et al., 2004), strength (Dziados, 1987; Harman et al., 2008; Knapik et al., 1990; Kraemer et al., 2004; Marriot & Grumstrup, 1992), muscle mass (Knapik, 1990; Marriott & Grumstrup-Scott, 1992), and body size (Marriott & Grumstrup-Scott, 1992) were factors related to the loaded foot march performance. To support this contention that strength is important and endurance is not the limiting factor in military tasks an Australian group of researchers evaluated the task of assaulting an objective. Assaulting involves short high intensity sprints from cover to cover or prone to prone fighting positions.

Silk and Billing, (2013) evaluated mock assaults of 100-150 m with 22-32 kg load (depending upon the individual's role in the squad). The results suggest that the task of assaulting 100-150 m took about 6.5 minutes with a one: four work to rest ratio that resulted in heart rate being elevated to 75 % of heart rate reserve (Silk & Billing, 2013). The task of moving for short durations as quickly as possible with a 22-32 kg load did not markedly stress the cardiovascular system. Therefore, it is interpreted that assaulting is not limited by aerobic fitness.

Trainability of Performance Variables

Muscular Strength, Power, and Endurance

Strength and power have been suggested to be important characteristics to athletic performance (Barker et al., 1993; Hoffman, Tenenbaum, Maresh, & Kraemer, 1996; Yoon, 2002); therefore, strength and power may well be related to military operations. Strength and power can be evaluated through the vertical jump assessment. There are numerous ways to conduct physical fitness training to improve vertical jump height. According to Clutch, Wilton, McGown, and Bryce (1983) performing maximum effort vertical jumps, depth jumps from 0.3 m and 0.75 m may increase vertical jump height. Weight training has also been suggested to increase vertical jump height (Fatouros et al., 2000). One caveat to body weight or plyometric training is the limitation of overload. The lack of overload in body weight and plyometric training may limit improvements in vertical jump height, although body weight training may increase muscular endurance. According to Anderson and Kearney (1982) high repetition-low resistance training increased relative endurance and absolute endurance to a greater extent than high resistance-low repetition, although there was no statistically significant difference for absolute muscular endurance. This suggests that both high resistance-low repetitions and low resistance-high repetition training will increase absolute muscular endurance to a similar extent. The push-up and sit-up scores may be increased with either mode of training.

Aerobic Power and Lower Extremity Endurance

Improvements in 2-mile run time can be improved through three different methods of training. High intensity interval training is characterized by brief intermittent exercise performed at a maximal or near maximal effort at an intensity greater than 90% of VO_2 peak (Gibala & McGee, 2008). High intensity interval training has been shown to be effective at improving endurance running performance (Laursen & Jenkins, 2002; Weston et al., 1996). It is common knowledge that low intensity, high mileage running may increase endurance running performance but possibly at the cost of injury due high volume of training. Last, explosive strength training in conjunction with run training has been shown to improve 5km running performance through improved running economy (Paavolainen, Häkkinen, Hämäläinen, Nummela, & Rusko, 1999). It is also interesting to note that runners with an increased vertical jump height tend to be faster runners in 800, 3000, and 5000 m races (Hudgins, Scharfenberg, Triplett, & McBride, 2013). This suggests that strength and power training may have a positive effect on 2-mile performance but improvements in endurance running performance do not increase muscular strength and power (Leveritt, Abernethy, Barry, & Logan, 2003) and may interfere with improvements in strength and power (Häkkinen et al., 2003; Leveritt, Abernethy, Barry, & Logan, 1999).

Body Composition

Body composition doesn't constitute just fat mass but also include lean or muscle mass. Lean mass is every tissue that is not fat mass while muscle mass only includes muscle. The type of training undertaken will largely determine specific adaptations (Nader, 2006). The two extremes of training are endurance training and weight training, characterized by sustained (minutes to hours) repetitive movement at low intensity levels and short duration high to maximal effort intensities, respectively. Research on the effects of endurance training on muscle mass suggests that endurance training can result in no change (Carter, Rennie, Hamilton, & Tarnopolsky, 2001) or a reduction in muscle mass. On the contrary, resistance training has been shown to increase muscle mass (Narici, Roi, Landoni, Minetti, & Cerretelli, 1989). While changes in lean mass or muscle mass can be positively affected by resistance training, both endurance and resistance training can affect body fat, although caloric intake and nutrient timing may play a larger role in changing fat mass.

Sandhurst Competition

The Sandhurst Competition is an event that has been taking place annually since 1967. The Sandhurst Competition encompasses several challenges like rappelling, building and crossing a one rope bridge, land navigation, marksmanship, 12’ raft paddle, weapons handling skills, loaded foot marching, and the obstacle course. These events are subject to change because one objective of the competition is to force cadets to think on their feet. Cadets are expected to react to specific challenges as opposed to perform a known task.

The Sandhurst Competition is comprised of teams from all over the world. Each team is allowed nine competitors, one must be female, and there are two alternates. There is a selection process where teams outside of West Point Military Academy have to win a smaller, yet similar, competition to make them eligible for the Sandhurst Competition. All West Point teams have the opportunity to compete in Sandhurst Competition without having competed in a previous competition.

Literature elaborating on the events of the Sandhurst Competition is nonexistent. Therefore, anecdotal separation of tasks into physical and tactical has been made. Tactical skills include one rope bridge, rappelling, weapons handling skills, land navigation, and marksmanship. These tasks are more likely to be dependent upon tactical and technical skills rather than physical characteristics. Regardless, these skills are evaluated in respect to the physical performance measures attained prior to competition. There may be certain physical characteristics that are related to these particular skills of which the researcher is unaware.

The physical tasks include the 12’ raft paddle, loaded foot march, grenade toss, 12’ wall climb, and the obstacle course. The 12’raft paddle requires the team to load their equipment into the raft, carry it to the water, paddle a designated course, and carry the raft back ashore in the shortest time possible. The loaded foot march consists of traversing ~8 miles with a combat load. There are stops along the march where cadets perform the tasks previously mentioned. The obstacle course consists of numerous challenges that include, climbing, lifting, pushing, and pulling their body over and under certain obstacles. The obstacle course is also timed.

The Sandhurst Competition is an attempt at simulating real situations that military personnel will encounter during their service. Therefore, information concerning physical characteristics related to overall performance and individual events may give insight into characteristics on which military organizations should focus.

Summary

The previous literature identifies physical and performance characteristics of individual athletes and military personnel that may make better athletes and soldiers, although conducting military operations soldiers will rarely, if ever, perform on their own. Even the smallest of teams (sniper teams) will have at least two soldiers. Therefore, the purpose of this study is to identify the potential effects of physical and performance characteristics of the team competing in the Sandhurst Competition.

Hypotheses

Article #1.

Relationship between physical and performance characteristics of male Army ROTC cadets.

- There will be statistically significant positive correlations between push-up score, sit-up score, run score, and total score.

- There will be little to no significant correlations between measures of countermovement vertical jump (CMJ) and push-up score, sit-up score, run score and total score.

Article #2.

Identification of the differences in physical and performance characteristics between the winning team and remain teams at the Sandhurst Competition.

- Statistically significant differences will be found in APFT measures, CMJ measures, and body composition between the winning team and remaining teams.

Article #3.

Comparison of top three teams vs. bottom three teams in the Sandhurst Competition.

- Statistically significant differences will be found in APFT measures, CMJ measures, and body composition between the top three teams and bottom three teams.

CHAPTER 2

STUDY I

RELATIONSHIP BETWEEN PHYSICAL AND PERFORMANCE CHARACTERISTICS OF MALE ARMY ROTC CADETS.

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Prepare for submission to *Journal of Military Studies*

ABSTRACT

The purpose of this investigation was to identify the relationship between Army physical fitness test (PFT) scores, measures of strength and power, and anthropometrics. Correlation analysis identified statistically significant relationships between events of the PFT and low correlations between PFT events and measures of strength and power. The correlations suggest that a cadet that does well on one event of the PFT will likely score well on all events of the PFT. The lack of correlations between PFT and measures of strength and power suggest that the PFT does not adequately assess strength and power.

Key Words: *Army physical fitness test, strength and power, military fitness*

INTRODUCTION

The Army Physical Fitness Test (APFT) has been well studied. The APFT has been used to evaluate changes in recruit fitness to determine more efficient ways of training (Knapik et al., 2003, 2009). Furthermore, the APFT events have been evaluated to determine physical characteristics that are being assessed with each event. Batchelor, (2008) concluded that the APFT is an evaluation of muscular endurance and aerobic power. This coincides with the Army physical fitness manual TC 3-21.20 that suggests that the APFT is an evaluation of muscular endurance and aerobic power (Department of the Army, 2010). Aerobic power and muscular endurance could be considered similar characteristics due to the necessary muscular endurance required to evaluate aerobic power.

Push-ups, sit-ups, and running have been compared to combat related qualities such as lifting a box and carrying objects for distance (Hodgdon, 1992; Rayson et al., 2000), foot marching (Rayson et al., 2000), and body composition (Hodgdon, 1992; Mello, Murphy, and Vogel, 1984; Rayson et al., 2000). In all of these studies the authors did not report the relationship between the events of the physical fitness test.

A study by Esco, Olson, and Williford, (2008) found a strong positive correlation between 60 sec of push-ups and sit-ups. Sixty seconds of push-ups and sit-ups may not be the exact time of the APFT push-up and sit-up test but this does provide some indication that if a soldier does well on one event they should do well on the other. In another study one minute of sit-ups, isometric push-up and 6 (6-8 y/o) or 9 (9-18 y/o) minute run for distance were correlated among youth with mild intellectual disabilities. Correlation between run and sit-ups (r=0.32), run and push-up (r= 0.29), and push-up and sit-ups (r= 0.19) were statistically significantly correlated (Frey and Chow, 2006). This study does not show strong correlations but this may be due to sample size (n=444) and study sample.

Although the APFT has been well studied; to the researcher's knowledge APFT scores have not been correlated to each other. The purpose of this study is to determine the relationship between APFT events, measures of strength and power, and body composition. The literature suggests that the physiological characteristics that allow individuals to perform well on the test are very similar. Therefore, it is hypothesized that relationships between APFT measures will be strong and statistically significant.

METHODS

Participants

Participants consisted of 72 male cadets from Army ROTC units all over the United States. These 72 participants were only the male cadets from nine teams that competed in the Sandhurst Competition. Prior to participation, all subjects read and signed informed consent documents that were approved by the Keller Army Hospital Institutional Review Board.

Data Collection

Age.

Cadets reported their age the day of the Sandhurst competition.

Height.

Height was assessed using a metric tape that will be attached to the wall. Height was assessed to the nearest 0.5 cm. Shoes were removed with heels touching each other and against the wall. Participants were instructed to stand tall with head and eyes looking forward.

Body Mass.

Mass was assessed with the participant wearing shorts and t-shirt for males and females. Mass was measured to the nearest 0.1 kg on a balance scale (Detecto-Medics, Brooklyn, NY).

Waist Circumference.

Waist circumference was assessed using a metric fabric tape measure. Measurements were taken at the umbilicus with the participants arms at their side. Measurements were recorded to the nearest half centimeter.

Waist to Height Ratio.

Waist to height ratio is an evaluation used to determine health risks. Waist to height ratio was calculated as follows:

Waist to Height Ratio = Waist circumference (cm) / Height (cm)

Standard Warm up Protocol for Vertical Jump Evaluation

Participants performed a standard warm-up protocol prior to vertical jump evaluations. The warm up consisted of 25 jumping jacks followed by one 75 % effort jump unloaded (0 kg) and one jump with maximal effort unloaded (0 kg). Between the unloaded and loaded (20 kg) condition, one loaded jump at 75 % effort was performed for familiarization prior to maximal effort loaded (20 kg) jumps.

Vertical Jump Protocol.

After the standard warm up the cadets started the vertical jump protocol that includes countermovement jumps (CMJ) with 0 kg (PVC pipe) or 20 kg (empty weightlifting bar) loads. The cadets were instructed to put the PVC pipe across their back at the thoracic vertebrae 1 level (“Put the bar across your back as if you were going to do a squat”). The cadet’s hands were placed on the bar to limit the use of any arm swing that may potentially increase jump height. This was the bar and hand placement for all vertical jump conditions.

Prior to the start of a new jump, one familiarization/warm up trial was conducted at 75 % of max effort. Cadets are then familiarized to the series of commands for vertical jump evaluation. The commands are as follows: Step on the mat, hold still, and then a countdown of “3, 2, 1, jump” followed. On the command “jump” the cadet jumped with 75 % effort (warm up) or maximal effort (data collection) depending upon the situation. Each cadet performed a minimum of three maximal jumps at each condition, with each weight. All jumps were averaged and used for data analysis. Requisition for an additional attempt would include jumping without their heels being in contact with the mat, jumping forward, or lack of effort perceived by the clinician or cadet (indicated by greater than 5 cm difference). Data from all jumps were measured with a switch mat (Just Jump Systems, Huntsville, AL). This protocol was a modified version of that used by Kraska et al., (2009). Flight time was recorded for each jump. Flight time was then used to calculate vertical jump height from the formula:

Vertical jump height = (g X flight time X flight time)/8 (Car lock et al., 2004)

Strength.

Strength was not assessed directly during data analysis. Unloaded (0 kg) CMJ is an assessment of lower body power (Everett A. Harman, Rosenstein, Frykman, Rosenstein, and Kraemer, 1991). The loaded (20 kg) CMJ may be considered an estimate of strength and power (Kraska, 2009). Kraska et al. (2009) found strong relationships between force characteristics and vertical jump height. Additionally, they (Kraska et al. 2009) showed that stronger athletes had less fall-off in vertical jump height and power as the jump-load increased. If the loaded CMJ height is subtracted from the unloaded CMJ height, the result is an assessment of strength. Evaluation of 124 athletes and cadets suggested there was a strong relationship between isometric peak force and percent fall off from 0-20 kg jump height (r=0.55 CMJ and r=0.52 SJ) (unpublished data from our lab). Thus, if the loaded countermovement jump height is subtracted from the unloaded countermovement jump height, the result can be interpreted as an estimate of relative strength (Kraska et al. 2009).The calculation used for determining strength is:

Percent Fall Off = Unloaded CMJH (0 kg) - Loaded CMJH (20 kg) / Unloaded CMJH (0 kg) x 100

Physical Fitness Test.

ROTC leaders from each team reported the most recent PFT scores for all of the participants. Physical fitness tests were conducted within two months prior to the competition. The PFTs were conducted in accordance with the guidelines provided by the TC 3-22.20 (Department of the Army, 2010) or respective physical fitness testing doctrine.

Assumptions

There are several different military branches that comprise the participants of the study. It is well known that each military branch has a slightly different physical fitness test but include the activities of push-ups, sit-ups, and running. Therefore, the researchers assume that a cadet that scores well on their respective military branch PFT would also score well on another military branch PFT, since the events are similar.

Limitations

A limitation of the study results from cadets scoring the maximal number of push-ups, sit-ups or running a maximum scoring time. First, cadets are discouraged from doing more push-ups or sit-ups than would equal the maximum score because it does not relate to more points on the PTF. Second, most cadets participating in this event are the best at their respective unit/university and therefore score very close to the maximum points on the PFT. With all of the high scores identifying meaningful relationships between characteristics becomes difficult.

Statistical Analysis

A Pearson Product-Moment Correlation Coefficient was performed to determine relationships between physical and performance characteristics of male Army ROTC cadets. Statistical significance was set at $p \leq 0.05$. The strength of correlation has been identified: small, $r = \pm 0.1\text{-}0.3$; medium $r = \pm 0.3\text{-}0.5$; and large, $r = \pm 0.5$ or greater.

RESULTS

Table 2.1 Descriptive Statistics of all Participants

Descriptive Statistics	
	Mean±SD
Push-up Number	77.23±9.52
Push-up Score	98.15±3.89
Sit-up Number	85.34±11.21
Sit-up Score	97.43±5.00
Run Time	755.61±45.52
Run Score	97.96±4.83
Total Score	293.55±9.35
Age	20.92±1.66
Height (cm)	177.09±7.17
Mass (kg)	80.31±6.95
Waist Circumference (cm)	83.40±4.78
0kg CMJ Flight Time (s)	0.61±0.04
0kg CMJ Jump Height (m)	0.46±0.05
20kg CMJ Flight Time (s)	0.53±0.03
20kg CMJ Jump Height (m)	0.35±0.05
Percent Fall Off	24.24±4.33
Waist to Height Ratio	0.47±0.03

Table 2.2 Correlation matrix

Correlations

	Push-up Number	Push-up Score	Sit-up Number	Sit-up Score	Run Time	Run Score	Total Score	Age	Height	Body Mass	Waist Circumference	0kg CMJ Flight Time	0kg CMJ Jump Height	20kg CMJ Flight Time	20kg CMJ Jump Height	Percent Fall Off	Waist to Height Ratio
Push-up Number	1																
Push-up Score	.637**	1															
Sit-up Number	.487**	.268*	1														
Sit-up Score	.295*	.298*	.678**	1													
Run Time	-.346**	-.284*	-.307**	-.255*	1												
Run Score	.260*	.236*	.128	.072	-.793**	1											
Total Score	.557**	.698**	.540**	.696**	-.664**	.653**	1										
Age	.026	-.094	.122	-.015	-.002	-.018	-.056	1									
Height	-.248*	-.161	-.112	-.095	.006	.009	-.113	.090	1								
Body Mass	-.083	-.115	-.088	-.092	.270*	-.256*	-.230	.328**	.629**	1							
Waist Circumference	-.210	-.171	-.051	.081	.212	-.163	-.112	.275*	.166	.592**	1						
0kg CMJ Flight Time	.196	-.065	-.011	-.188	-.015	-.052	-.155	.034	.129	-.006	-.311**	1					
0kg CMJ Jump Height	.185	-.052	-.005	-.189	-.011	-.067	-.157	.006	.118	-.014	-.310**	.995**	1				
20kg CMJ Flight Time	.151	-.084	.040	-.147	.007	-.101	-.166	.057	.188	.139	-.180	.896**	.897**	1			
20kg CMJ Jump Height	.129	-.112	.038	-.135	.013	-.120	-.181	.066	.187	.145	-.167	.891**	.893**	.993**	1		
Percent Fall Off	.060	.112	-.078	-.060	-.046	.120	.077	-.142	-.190	-.364**	-.249*	-.046	-.044	-.472**	-.480**	1	
Waist to Height Ratio	-.023	-.052	.012	.114	.200	-.162	-.045	.186	-.504**	.119	.763**	-.355**	-.346**	-.276*	-.264*	-.097	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Physical Fitness Test

Correlations between PFT scores were statistically significant. Correlations ranged from r= .236-.698. Push-up number and height are inversely statistically correlated at r= -.248. Weight is inversely statistically significantly correlated to run score. There were no statistically significant correlations between PFT scores and CMJs or percent fall off.

Countermovement Jump

There were no significant correlations between vertical jump measures (0 kg, 20 kg, or % fall off) and PFT measures (r= -0.189 to 0.196).

Age

Age was statistically correlated to body mass and waist circumference (r= .243-328) although, relatively small.

Height/Body mass

Height was statistically correlated to body mass (r= .629), lean mass (r= .676), waist to height ratio (r= -.504), and lean mass to height ratio (r= .287). Body mass was statistically correlated to waist circumference (r= .592) and percent fall off (r= -.364).

Waist to Height Ratio

Waist to height ratio was statistically correlated to percent body fat (r= .865) and fat mass (r= .814).

DISCUSSION

Physical Fitness Test

A review of the current literature showed that a correlation analysis between physical fitness test scores has not been done. Sixty seconds of push-ups and 60 seconds of sit-ups have been evaluated and showed a strong positive correlation (r= 0.65) (Esco et al., 2008). The strong positive correlations between physical fitness test events in this study suggest that the events evaluate similar physical characteristics; muscular endurance. The statistically significant correlations found in this analysis are also supported by factor analysis of 104 data sets from 53 Army ROTC cadets (Figure 2.1)that found the PFT evaluates very similar characteristics (unpublished data from East Tennessee State University, Sport Science Lab). Intuitively, performing just one event of the PFT should provide similar determination of physical fitness abilities as performing all three events.

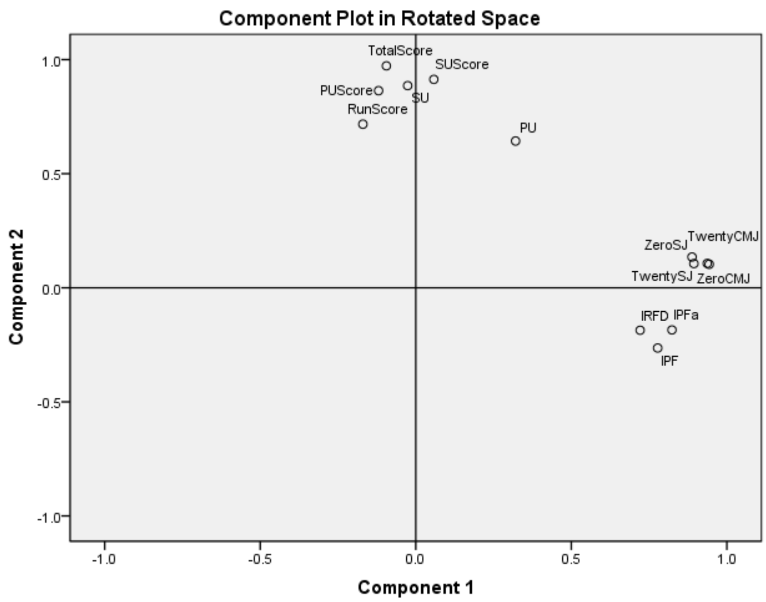

Figure 2.1 Factor analysis of APFT measures of 104 ROTC cadets. PU= Push-up raw number, SU= Sit-up raw number.

In another study, (Frey and Chow, 2006) one minute of sit-ups, isometric push-up and 6 (6-8 y/o) or 9 (9-18 y/o) minute run for distance were correlated among youth with mild intellectual disabilities. Correlation between run and sit-ups (r=0.32), run and push-up (r= 0.29), and push-up and sit-ups (r= 0.19) were statistically correlated (Frey and Chow, 2006). Although the push-up, sit-up and run test are slightly different and the correlations slightly weaker, the correlations are still similar to what was found in this study.

In a study that evaluated 102 Navy personnel (64 men and 38 women) in 2 minute sit-ups, 2 minute push-ups, one and a half mile run, percent body fat, fat free mass; fat mass, and box lift weight. The box lift weight was the maximum load that could be lifted to elbow height. The box lift weight was correlated to sit-ups (r=0.00), push-ups (r=0.63), and run time (r= -0.34), (Hodgdon, 1992). The study by Hodgdon, (1992) found slightly different results than was seen in this study. Hodgdon, (1992) used box lift task as an evaluation of strength which incorporates upper-body musculature. The box lift task seems to be a strength task based on the strong positive correlation to lean mass. This may explain the strong correlation between box lift (strength) and push-ups that was not seen in the present study. In the present study the correlation between sit-ups and strength and power were similar (r= -.078 to 0.04). The present study did not find strong positive relationships between push-ups and strength or power possibly due to the nature of the test. The push-up test assesses upper body musculature and the vertical jumps evaluate lower body musculature. The discrepancy may be due to the use of upper-body musculature in the box lift task, compared to the unloaded and loaded jumps used in this study. The run time in the current study was not statistically correlated to measures of strength and power which is somewhat unusual (Paavolainen et al., 1999). Some research has suggested that strength training (Paavolainen et al., 1999) and having greater levels of strength (Kong and De Heer, 2008) may improve run time.

Another study examining one minute of push- up and bench press strength of 1 repetition maximum (1RM) found a strong positive correlation between push-ups and bench press strength (r=0.55). The strength of their correlation to bench press strength improved when push-up number was divided by body mass (r=0.75) (Invergo, Ball, and Looney, 1991). Correlations in the present study did not reveal strong positive correlations between push-ups and measures of strength. This adds to the literature that the push-up test is not an evaluation on strength. The test used by Invergo et al., (1991) assessed upper body muscular strength via the bench press which is very similar to the movement pattern of a push-up. The CMJs used in the present study evaluate the lower body musculature and this may have led to the discrepancy between studies.

A unique correlation is the weak relationship between age and PFT scores. One would expect that as a cadet enters the ROTC program they would improve their PFT scores as they conducted more and more years of Army guided physical fitness. Possible reasons for such low correlations are the high physical fitness abilities in this sample of participating cadets or the PFT are not very stringent. Unpublished physical fitness test records from East Tennessee State University show that many cadets can attain the maximum or near maximum points on the PFT with just a few months of training. Further research should evaluate the changes in PFT scores with increasing years of Army guided physical fitness training.

There were weak correlations between PFT scores and vertical jumps and strength. Physical fitness training may influence the physical abilities of the cadets. Due to similar physical fitness training regimens, cadets are a very homogenous group in terms of vertical jump height and percent fall off. The Army strength training program is focused on calisthenics (Department of Defense, 2011), which may limit strength and power development and as a result may limit cadets ability to jump. A study of male and female collegiate athletes Kraska et al. (2009) identified a percent fall off of 17.4±4.81 % in the top six strongest athletes and a 34.5±7.76 % in the six weakest athletes. In the current study percent fall off for the male only population was 24.2±4.42 %. According to Harman et al., (2008) body weight exercise has been suggested to limit strength and power development while strength training with weights can progress to an almost infinite extent. The narrow range of jump heights and PFT scores may limit the effectiveness of correlation analysis to identify strong relationships.

The low correlations between PFT measures and vertical jumps or percent fall off (power and strength, respectively) suggest that the PFT is lacking a measure of strength and power because the duration of each event is too long to evaluate strength or power. The literature supports the notion that the PFT does not evaluate strength or power (Batchelor, 2008; Department of the Army, 2010). The literature also suggests military tasks are strength dependent (Batchelor, 2008; Forman, 1997; Knapik et al., 2009; Rayson et al., 2000). The military provides unit commanders with a PFT that evaluates, “general fitness, and is not a combat fitness test” (Forman, 1997). The deficiency in the PFT leaves unit commanders with no guidance on how to evaluate combat readiness.

Anthropometrics

The correlations, found in this study, between anthropometrics and PFT scores range from r= -.215 to r= .209. The physical fitness training program emphasizes muscular endurance and aerobic fitness. As cadets continue to specialize in specific physical fitness training their body begins to develop similar abilities. Second, the Army’s height and weight standards may also be a contributing factor to the similarities in body composition among cadets.

The statistically significant but inverse relationship between push-up score and height provide indication that height may positively or negatively affect performance on the push-up event. Shorter cadets may benefit from a mechanical advantage of having a shorter distance between their hands and feet (axis of rotation) and may have shorter limbs which decreases the distance in which they have to move their body mass. Mass is another variable that negatively affected running performance. The results suggest that having a lower body mass is advantageous to scoring more points on the 2-mile run. The literature suggests an importance on having greater lean mass for military operations (Marriott and Grumstrup-Scott, 1992; Rayson et al., 2000). It’s counterintuitive to evaluate the physical fitness of soldiers with a test that favors soldiers that are lighter and less mass.

In a study that evaluated the relationship between VO_2 peak and 2-mile run time, Mello et al., (1984) provided a correlation matrix of other measured height mass, percent body fat, and lean body mass. Mello, Murphy, and Vogel, (1984) found a strong positive relationship between height and weight (males, r=0.6) which is almost exactly the same correlation found in this study (r=0.629).

Summary

The strong positive correlations between PFT scores suggest that only one event may be required to determine military defined physical fitness. The lack of correlations between APFT measures and strength and power measures suggests that the events of the APFT do not assess vital fitness characteristics that have been shown to influence completion of military tasks.

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CHAPTER 3

STUDY II

IDENTIFICATION OF DIFFERENCES BETWEEN THE WINNING TEAM AND REMAINING TEAMS IN THE SANDHUST COMPETITION

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ABSTRACT

The purpose of this investigation was to determine differences in physical and performance characteristics between the winning team of the Sandhurst Competition and all remaining teams. Teams competed in a simulated 2 day military operation where each event was objectively scored. Thirteen teams participated in the study out of 55 competing teams. Each team consisted of nine participants; eight male and one female. Statistically significant differences were found between the winning team and most teams in respect to age. The winning team was older and potentially more experienced than most teams. Two other teams had high mean age and placed 2nd and 10th in the overall competition. No other differences were found in physical or performance characteristics. The results suggest future teams should select older more experienced team members.

Key Words: *age effect, experience, military fitness, military skills*

INTRODUCTION

Age may play a large role in the performance of military tasks. A comparison of the age of two different groups of military operators suggests that age may be one indicator of superior military performance. In a study on the physical effects of a nine month deployment to Afghanistan the mean age of the 2^{nd} Battalion, 4^{th} Infantry Regiment of the 10^{th} Mountain Division was 23.1 ± 4.7 (Sharp et al., 2008). An evaluation of the physical demands of Navy SEALS revealed that the mean number of years' experience was 11 (Prusaczyk et al., 1995). The participants in the study by Sharp et al., (2008) could have only had, on average five years of experience since you must be 18 to be accepted into the military. One reason the reasons the Navy SEALS operators are part of an elite fighting unit is due to the age and experience they have developed throughout their career.

Ericsson, (2006) suggests that mastery of a skill; requires not only experience but, knowledge, and deliberate practice. Throughout a military career cadets and soldiers are placed in specific training exercises designed; a) to develop experience executing military skills and b) to build knowledge of efficient strategies for completing a task. With increased time and repetition performing military skills or tasks, soldiers are better able to handle different situations presented to them. This suggests that as cadets and soldiers progress through their training and get older their skills will improve concomitantly.

Research evaluating differences between novice, sub-elite, and elite rugby athletes suggest that age may differentiate between each level of competition (Gabbett, 2009; Gabbett, Kelly, Ralph, and Driscoll, 2009). Most sports programs around the world have age group categories due to the understanding that as adolescents develop, "increases in chronological age are related to increased physical and mental development" (Barnsley, Thompson, and Legault, 1992). Thus, age and subsequent physical and mental development may explain differences between successful and less successful athletes. Using analysis of what is considered the "relative age effect" numerous authors contend that age may influence the ability to develop skills and future success (Barnsley et al., 1992; Helsen, Van Winckel, and Williams, 2005; Musch and Grondin, 2001; Thompson, Barnsley, and Stebelsky, 1991; Vincent and Glamser, 2006). Age and experience may provide an advantage but physical and physiological variables may also influence the ability to successfully complete a task.

Researchers have shown that both aerobic fitness (Marriott and Grumstrup-Scott, 1992; Rayson et al., 2000) and strength (Batchelor, 2008; Forman, 1997; Knapik et al., 2009; Marriott and Grumstrup-Scott, 1992; Rayson et al., 2000) were linked to successful performance on military tasks. Attempts to evaluate physiological characteristics that are necessary for soldier performance are numerous. Researchers have evaluated physical fitness changes from pre to post deployment in an and found that strength and power were maintained or improved while aerobic fitness decreased (Lester et al., 2010; Sharp et al., 2008). Researchers have also identified statistically significant relationships between lean mass and aerobic fitness and foot marching (Rayson et al., 2000), and between lean mass and the ability to lift and carry objects (Hodgdon, 1992; Rayson et al., 2000). Researches also ask Navy SEALS about their perceptions of physical demands of combat operations who suggested aerobic fitness was the primary fitness characteristics used and strength was secondary (Prusaczyk et al., 1995). Even with all of these attempts to identify physiological characteristics there is still a discrepancy as to which characteristics are most important.

Research evaluating the characteristics of individual soldiers suggests that age or experience, aerobic fitness, muscular strength, and fat-free mass may be important for combat operations or mission essential tasks. This is vital information although, soldiers rarely, if ever, perform military operations independently. A thorough review of the literature revealed no studies that evaluated team physical characteristics on athletic team performance or on simulated combat operation skills or tasks.

The purpose of this study is to evaluate differences between physical and physiological characteristics of the winning team of the Sandhurst Competition with the characteristics of the remaining teams. This study attempts to identify qualities that make a successful team when performing military tasks from the rest.

METHODOLOGY

Participants

Participants consisted of 117 cadets (male=104; female=13) from ROTC units all over the world. These 117 participants made up 13 teams that competed in the Sandhurst Competition. There are nine cadets in each team comprising of eight male cadets and one female cadet. Each team's data was averaged to represent their respective team. Prior to participation, all subjects read and signed informed consent documents that were approved by the Keller Army Hospital Institutional Review Board.

Testing

Height.

Height was assessed using a metric tape that will be attached to the wall. Height was assessed to the nearest 0.5 cm. Shoes were removed with heels touching each other and against the wall. Participants were instructed to stand tall with head and eyes looking forward.

Body Mass.

Mass was assessed with the participant wearing shorts and t-shirt for males and females. Mass was measured to the nearest 0.1 kg on a balance scale (manufacture and model).

Waist Circumference.

Waist circumference was assessed using a metric fabric tape measure. Measurements were taken at the umbilicus with the participants arms at their side. Measurements were recorded to the nearest half centimeter.

Waist to Height Ratio.

Waist to height ratio was an evaluation used to determine health risks. Waist to height ratio was calculated as follows:

Waist to Height Ratio = Waist circumference (cm) / Height (cm)

Standard Warm up Protocol for Vertical Jump Evaluation

Participants performed a standard warm-up protocol prior to vertical jump evaluations. The warm up consisted of 25 jumping jacks followed by one 75 % effort jump unloaded (0 kg) and one jump with maximal effort unloaded (0 kg). Between the unloaded and loaded (20 kg) condition, one loaded jump at 75 % effort was performed for familiarization prior to maximal effort loaded (20 kg) jumps.

Vertical Jump Protocol.

After the standard warm up the cadets started the vertical jump protocol that includes countermovement jumps (CMJ) with 0 kg (PVC pipe) or 20 kg (empty weightlifting bar) loads. The cadets were instructed to put the PVC pipe across their back at the thoracic vertebrae 1 level ("Put the bar across your back as if you were going to do a squat"). The cadet's hands were placed on the bar to limit the use of any arm swing that may potentially increase jump height. This was the bar and hand placement for all vertical jump conditions.

Prior to the start of a new jump, one familiarization/warm up trial was conducted at 75 % of max effort. Cadets were then familiarized to the series of commands for vertical jump evaluation. The commands are as follows: Step on the mat, hold still, and then a countdown of "3, 2, 1, jump" followed. On the command "jump" the cadet jumped with 75 % effort (warm up) or maximal effort (data collection) depending upon the situation. Each cadet performed a minimum of three maximal jumps at each condition, with each weight. All jumps were averaged and used for data analysis. Requisition for an additional attempt would include jumping without their heels being in contact with the mat, jumping forward, or lack of effort perceived by the clinician or cadet (indicated by greater than 5 cm difference). Data from all jumps were measured with a switch mat (Just Jump Systems, Huntsville, AL). This protocol is very similar to that used by Kraska et al., (2009). Flight time was recorded for each jump. Flight time was then used to calculate vertical jump height from the formula:

Vertical jump height = (g X flight time X flight time)/8 (Jon M. Carlock et al., 2004)

Strength.

Strength was not assessed directly during data analysis. Unloaded (0kg) countermovement jump can be used as an assessment of lower body power (Everett A. Harman, Rosenstein, Frykman, Rosenstein, and Kraemer, 1991). The loaded (20kg) countermovement jump may be considered an estimate of strength and power (Kraska 2009). Kraska et al. (2009) found strong relationships between force characteristics and vertical jump height. Additionally, they (Kraska et al. 2009) showed that stronger athletes had less fall-off in vertical jump height and power as the jump-load increased. Furthermore, in an assessment 124 athletes and cadets there was a strong relationship between isometric peak force and percent fall off from 0-20 kg jump height (r= 0.55 CMJ and r= 0.52 SJ) (unpublished data from our lab). Thus, if the loaded countermovement jump height is subtracted from the unloaded countermovement jump height, the result can be interpreted as an estimate of relative strength (Kraska et al. 2009). The calculation used for determining strength is:

Percent Fall Off = Unloaded CMJH (0 kg) - Loaded CMJH (20 kg) / Unloaded CMJH (0 kg) x 100

Physical Fitness Test.

ROTC leaders from each team reported the most recent physical fitness test (PFT) scores for all of the participants. Physical fitness tests were conducted within two months prior to the competition. The PFTs were conducted within the guidelines provided by the TC 3-22.20 (Department of the Army, 2010) or respective physical fitness testing doctrine.

Assumptions

There are several different military branches that comprise the participants of the study. It is well known that each military branch has a slightly different physical fitness test but include the activities of push-ups, sit-ups, and running. Therefore, the researchers can assume that a cadet that scores well on their respective military branch PFT would also score well on another military branch PFT since the events are similar.

Limitations

A limitation of the study results from cadets scoring the maximal number of push-ups, sit-ups or running a maximum scoring time. First, cadets are discouraged from doing more than the maximum because it does not relate to more points on the PTF. Second, most cadets participating in this event are the best at their respective unit or university and therefore score very close to the maximum points on the PFT. With all of the high scores identifying meaningful relationships between characteristics becomes difficult.

The Sandhurst Competition 2013

Marksmanship

Situation. A Platoon sized Enemy element (approximately 20-25 insurgents) is suspected to be moving dismounted through AO SANDHURST with the intentions of crossing New York State (NYS) Route 293. The latest imagery shows the enemy Platoon moving through an open area dispersed to reduce their signature using local national farmers as guides to transit the AO. The insurgents are armed with AK47s. They are dressed in dark green military style clothing and the local farmers traditionally wear white clothing.

Mission. On order, your Squad defends the Battle Position (BP) at Range 5 against dismounted enemy personnel in order to prevent them from crossing NYS Route 293.

Key Tasks. Occupy battle position and establish hasty defense. Minimize collateral damage to the local population as they are believed to be intermixed with insurgent forces in the open area wearing white shirts. Utilize existing cover and concealed positions to defend Battle Position (BP) 1. Effects of your weapon systems will not enter adjacent platoon's battle space as they have established blocking positions to your left and right in order to prevent enemy reinforcements from influencing your position.

Execution and Constraints. Your Squad has 5 minutes to plan and be prepared to move to your link up point (at the command of the Briefing Area personnel). You will move dismounted to the link up point where you must occupy the BP immediately upon receiving your ammunition. Move straight from the link up point to the BP and behind cover. You will stow your ammunition on your person and only load your weapon when in the BP. You may move laterally within the BP, however you are not authorized to move forward of the firing line. You will hear an air horn blow at the BP when you are mission complete. Once mission complete you will lock and clear your weapons, safely move to the range tower with all of your magazines and remaining live ammunition to be counted by range personnel. The number of rounds you have remaining will be used in the event of a tie (reward for accuracy). Once cleared by range personnel at the range tower, you will immediately move off the range and toward your next check point (your time is still running). No loitering, remember you are on the clock at all times!

Safety Violations. Muzzle Awareness – Cadet is aware what is in front of, behind, and to the flanks of his or her target (example – individual ensures muzzle clears debris within BP prior to engaging targets).You will move dismounted to the link up point where you must occupy the BP immediately upon receiving your ammunition. Move straight from the link up point to the BP and behind cover. Weapon Orientation – Cadet maintains a safe orientation of his or her weapon system while engaging targets and moving within the BP (i.e. does not flag others). Weapon Status (Mechanical Safety) – Weapon remains on safe unless Cadet is actively engaging targets. Magazines are loaded and round is chambered only when Team has occupied BP (inserting a magazine into the magazine well prior to occupying the BP will result in automatic disqualification from the Sandhurst Marksmanship Competition). Weapons are placed on safe prior to any lateral movement within the BP. Hand Position – Finger remains outside of the trigger well until Cadet is actively engaging targets. Personal Protective Equipment (PPE) – All Cadets will wear the following PPE: ballistic helmet, eye protection, hearing protection, and load bearing equipment (gloves are optional). Additional Safety Information – Any act that a Range Safety deems as unsafe (and is not listed above) may result in a warning and / or penalty.

Penalties. Safety Violation (after initial warning)	-20 points
Shooting a non-combatant	-10 points
Loading a magazine prior to occupying the BP	Disqualification.

Rope Bridge

Situation. You have encountered a water gap crossing on your movement to the objective.

Mission. On order as quickly as you can, using onsite equipment and your Squad, construct a rope bridge across the water obstacle in order to safely continue onto your objective.

Constraints.

- You have no more than 7 minutes to complete this lane on the command of “go”.
- The rope bridge must be clear of the water, allowing a crossing without contact with the water.
- Only one person attached to the bridge at any one time.
- Only the first and last squad member may enter the gap/water while the bridge is anchored at one point. They must be attached to the bridge or a safety line whilst conducting the transit. These members must not transport the burden.
- Two anchor points must be established (one on the far side with at least 4 wraps and one on the near side).
- All equipment utilized will be recovered to the far bank.
- The rope bridge must be fully disassembled and recovered.
- The time of the rope bridge starts once the squad has assembled the Swiss Seats correctly and is given the words of command “GO”.

The team who crosses the gap with all of the equipment that they utilized in the fastest time (after subtraction of time penalties) wins the event.

Penalties.

- Loss of equipment in transit + 30 seconds each
- More than one person crossing at any one time + 5 minutes each

- Burden not transported across river (mission failure) + 5 minutes
- Far side anchor does not have 4 wraps of rope around the tree + 3 minutes
- Burden transported across by the first and/or last squad member + 7 minutes
- Improper Swiss Seat (Individual is held until deficiency is correct at the staging area)
- Personnel/Equipment who contact the water will start again from the home bank

Pistol Marksmanship

Timeline. You have 90 seconds for your team to read and organize for this mission.

Uniform. Eye and Ear Protection, Helmet and Load Bearing Equipment. Rifles must be slung across the back of all team members.

Situation. You are supporting a military police (MP) unit who is in danger of being overrun. All of your 5.56mm ammunition was spent in the defensive position you just departed. The MPs have left you M9 pistols and ammunition.

Mission. Immediately occupy your firing positions, secure and load your pistols, and on the command *"Watch and Shoot, Watch and Shoot,"* the lane will begin. Engage targets as they appear.

Execution/Constraints.

- Your team must be organized into seven firers and one weapons assembly person; squad leader must supervise everyone. The seven firers will cover down on a lane numbered 1 to 7 upon occupation of the site. Each firing point will have an M9 pistol and four magazines of seven rounds each prepositioned. The location of the each firing lane is denoted by a numbered sign while the actual firing point is denoted by a red dot just forward of the numbered signs on the path. Each lane's targets are color coded to that lane. Enemy targets will either be all green or all tan based on lane number. White targets denote civilians. Any shooting of a civilian target will carry a five point penalty for each hit.

- Pistol assembly will begin when the designated weapons assembly team member first touches any pistol component and concludes when the team member sets down the final assembled weapon. The team member must then execute an untimed function check on each pistol to verify to the grader that assembly was properly completed.
- On the Command *"Lock and Clear, Lock and Clear,"* the scenario is finished. Lock and clear your pistol, a range safety will inspect it, and then place the pistol back where you found it. Finally, move to the base of the tower for follow on instructions.

Penalties.

• Unsafe handling of pistol (flagging, dropping etc.)	-10 Points from lane score
• Any missing uniform item	-5 Points per incident
• Improper pistol assembly	-10 Points per occurrence

Start Point and End Point

Situation. Sandhurst competitors must undergo a Start Point and End Point equipment inspection on both days of the Sandhurst competition.

Mission. Teams will report to the Start Point at IVO MacArthur Statue and the Superintendent's House (WL87108280) at their prescribed starting time and undergo a comprehensive equipment inspection before starting. All deficiencies will be identified and annotated on the team's scorecard. Following the equipment inspection each team will clock out at the E-Punch station and navigate to the next event within the Sandhurst competition. Each team's time will be stopped when they report back to the E-Punch station following each day's events. The teams will once again undergo a comprehensive equipment inspection and all deficiencies will be identified and annotated on the team's scorecard.

Execution and Constraints.

- You must arrive at the Start Point and End Point with all your team members and all squad equipment in order to start and end each day of the competition.
- Teams are not authorized to possess personal global positioning systems, cell phones / phones and unissued maps.
- Assigned Start Point, End Point staff will escort each team thru the node.
- Teams must ensure they E-Punch their team's scorecard before departing and upon returning to the Start Point / End Point (on each day of the competition).

Penalties.

• Missing or unserviceable equipment	+30 sec each item
• Squad members not reflected on Squad roster	Disqualification

- Unapproved departure or interaction within the SP/EP +30 min/and or disqualification

- No female Squad members Disqualification

- Possession of unauthorized equipment Disqualification

- Missing Squad members Disqualification

DMI Challenge Lane

Situation. You must prepare your personnel for water operations and ensure they can efficiently move a zodiac boat for follow-on missions. However, you must cross a minefield to reach your boat.

Mission. PHASE 1: Move to your assigned lane on Daly Field by following the white engineer tape up the hill. Upon arrival to your lane, use the given equipment to move all team members and personal equipment across the minefield without any personnel/items touching the ground. Successfully move everyone across in 5 minutes and you will have a lighter boat for Phase 2. If the entire team does not cross the minefield in 5 minutes, you will be told to cease work and move to Phase 2. The penalty will be a heavier boat to carry. You may not skip this phase. PHASE 2: Move the Zodiac boat with all team equipment around the specified course which is marked by personnel in orange road guard vests. Any additional burdens in the boat will be determined by your performance during Phase 1. Final score is determined by overall time (plus penalties) which starts when you reach your lane on Daly Field and stops when Zodiac course is complete and equipment has been moved back to the exact spot where you picked it up.

Execution and Constraints.

- Team members/equipment may not touch the ground in the minefield
- The Zodiac boat must be carried. No Dragging
- Teams are not allowed to pour any water out of the water cans
- Personnel in orange road guard vests will tell you where to turn on the course
- Teams must follow the designated route
- Upon completion of the course, drop Zodiac and all burdens back in the exact spot where they were picked up

Penalties.

• Team takes longer than 4 minutes to reach Daly Field	+ 5 min
• Personnel/equipment touches ground in the minefield	+ 2 min (ea. occurrence)
• Dragging Boat	+ 5 min (ea. occurrence)
• Failure to move personal equipment/burdens on route	+ 5 min (ea. item)
• Purposely blocking the path of a faster team	+ 10 min (ea. occurrence)
• Moving off of designated route	+ 15 min (ea. occurrence)
• Water poured from water cans	Disqualification
• Skipping any phase	Disqualification
• Zodiac boat damaged	Disqualification

Land Navigation

Situation. You are at the Land Navigation site in the pre-event lane, which consists of three stations. Your time at each station is three minutes. When you hear the next whistle blast, proceed from the Map and Equipment Issue Station to the Water Resupply Station.

Mission. Your squad is allotted *120 minutes (2 hours)* of land navigation course time to locate up *to forty (40)* land navigation points using no more than two (2) cadre-issued P-cards and two (2) cadre-issued West Point Land Navigation Special, WGS-84 maps both of 1:10,000 (1:10K) scale. This is not a self-correcting course. Each P-card can only receive credit for a maximum of twenty (20) points.

Execution and Constraints.

- You may negotiate the course in 2 separate teams however each team must have at least 4 personnel.
- Each Land Navigation control point recorded on your P-card is worth one point.
- There are dummy control points on the course that DO NOT count towards your overall score, accurate navigation is essential.
- Control points on the course are only available during specific times – take note of the activation times listed for each point on your map (i.e. you must find the right point at the right time) – control points not found during this activation time window DO NOT count towards your final score.
- You may use only the cadre-issued maps!

Penalties.

- Unaccounted for personnel or equipment — Squad disqualification
- Unauthorized map use — Squad disqualification
- Collaboration with other Sandhurst teams — Squad disqualification
- Use of any type of non-issued GPS system — Squad disqualification
- Travelling in elements smaller than four per team — Squad disqualification
- Movement outside of course boundaries — Squad disqualification
- Exceeding course execution time of 120 minutes — -5 points assessed for each minute late
- Loitering at start or finish point (exceeds assigned prep times) — -1 point assessed for each 30 seconds

Hand Grenade

Situation. There are 5-7 enemy dismounts in the area manning 2 fortified bunkers and buildings. They have been observed with AK-47s and RPGs. Also, known enemy snipers are engaging friendly forces from the windows on the local buildings.

Mission. On orders, your squad (divided into 3, 3 man teams) approaches the three enemy positions. Conduct this movement in a concealed manner and engage with hand grenades in order to destroy the enemy.

Execution and Constraints.

- You must negotiate the course with your team, personal equipment, and weapon (ACH, eye pro, and gloves must be worn throughout the course). Secure 3 hand grenades for each member of your team and move out to your assigned lane.

- At your assigned lane identify your 3 targets. High crawl to your targets and maintain a low profile throughout the entire course. 1 hand grenade per person, per target.

- Each member of the team will engage 3 targets. You will throw from the back, kneeling and standing positions. After each member engages the target, each team of 3 will continue to rotate until all targets have been attempted. Only rotate when each team of 3 is ready. Once complete you and your team sprint to the check-out table.

Penalties.

- Unsafe handling of the hand grenade. Hand grenade detonates in the hand or on the ground in vicinity of soldier and team members Disqualification for that individual
- Exposure from covered position for more than 3 seconds -5 points each occurrence

- Soldier takes more than 15 seconds to prep and throw hand grenade -5 points

Incentives.

- Soldier scored 30 points +5 points
- Speed and overall score will determine the Hand Grenade winner.

Vertical Obstacle "The Wall"

Situation. Enroute back to your patrol base you encounter a wall obstacle.

Mission. On order your squad is to move over the wall and continue along your route.

Execution and Constraints.

- Time for the event began once the first member of the squad entered the mulch pit and stopped once all personnel and assigned equipment had safely cleared the wall and exited the pit.
- At no time could you have more than three Soldiers on the top of the wall.
- Positive control of equipment must be maintained at all times.
- Site safeties stopped any unsafe act or unsafe method of moving over the wall.
- Squad Leader was blindfolded.
- Only black parts of the wall are authorized to be used. Red areas were off limits.
- No more than 5 minutes were allowed to attempt to negotiate the wall.

Penalties.

- More than 3 Soldiers on top of the wall at any given time +30 sec each occurrence
- Loss of control of equipment (dropping, throwing it, etc) +30 sec each occurrence
- Any unsafe act determined by wall safety officer +30 sec each occurrence
- Moving over the wall in an unauthorized location +30 sec each occurrence
- Failure to complete event (5 minutes elapsed) zero points awarded

CBRN/Weapons Assembly

Situation. This lane will begin in 2 minutes. You have encountered a chemically contaminated environment. Prepare to conduct operations in a degraded environment. Ensure that all equipment is accounted for prior to executing this lane.

Mission. At the command of "GAS, GAS, GAS", be prepared to don your chemical protective mask. Once donned, do not remove your mask until instructed to do so. When you hear "STOP", cease all work and place your hands at your sides. Team members will then by instructed by the cadre to demonstrate that their mask is sealed.

Leave your mask on! Once instructed to do so by the cadre, move forward to the table and take instructions from your squad leader for weapons assembly. Once you have assembled all 5 weapon systems and performed a functions check, place all five weapons on the table and step back.

Execution and Constraints.

- You must negotiate this site with all team members and all personal equipment.
- Do not remove your mask until told to do so by cadre.
- All masks sealed within 9 seconds results in 100 points.
- Keep positive control of all pieces of each weapon system during assembly.
- Assemble all 5 weapon systems/conduct functions check in no more than 5 minutes; this will result in 100 points.

Penalties.

• Squad leader fails to achieve mask seal in 9 seconds	(-12 points)
• Squad member (each) fails to achieve mask seal in 9 seconds	(-11 points)
• Any piece of equipment on the ground at the 9 second mark	(-1 point per item)
• Removing a mask prior to being told to do so by cadre	(-20 points)
• Team Member fails to complete course	(-20 points)
• Team Member arrives without mask/cannot execute lane	(-20 points)
• Failure to properly assemble the M240B machine gun	(-30 points)
• Failure to properly assemble the M249 machine gun	(-25 points)
• Failure to properly assemble the M4 carbine	(-20 points)
• Failure to properly assemble the AK-47	(-15 Points)
• Failure to properly assemble the M9 pistol	(-10 points)
• Losing any part of a weapon system	Disqualification

Reconnaissance

Reconnaissance Patrol Debrief: Answer each question based on your patrol's observations. Turn in this debrief before you reach the finish line.

1. What small arms weapon systems does the enemy possess?

____

____

2. Does the enemy have armored vehicles? If so, what type and capabilities do they have?

____

____

____

____

3. What helicopters does the enemy have?

____

____

____

4. What fixed wing fighters does the enemy have?

____

5. Does the enemy have indirect fire systems? If so, what type and capabilities do they have?

____

6. Is there evidence of enemy naval activity on the major waterways along your route?

____

Statistical Analysis

A Multivariate ANOVA was performed to identify differences between the winning team and remaining teams. Post hoc analysis included a Bonferonni adjustment. Effect sizes were calculated via Cohen's d.

Cohen's d = (winning team mean - losing team mean) / √ (winning team standard devidation^2 + losing team standard deviation^2) / 2

RESULTS

Table 3.1 Descriptive Statistics of all Participants listed as Mean±SD, Minimum and Maximum Value, and Range

Descriptive Statistics				
	Mean±SD	Minimum	Maximum	Range
Age (yr)	21.14±1.91	18	28	10
Height (cm)	176.24±8.1	151	195	44
Weight (kg)	78.54±9.24	49.88	104.74	54.86
Waist Circumference (cm)	82.95±5.32	70	100	30
Push-up Score	97.02±6.27	69	100	31

Sit-up Score	97.18±5.6	71	100	29
Run Score	95.76±10.23	53	100	47
Total Score	289.97±18.01	206	300	94
0kg Vertical Jump Flight Time (s)	0.60±0.04	0.5	0.69	0.19
0kg Vertical Jump Height (m)	0.45±0.06	0.3	0.58	0.28
20kg Vertical Jump Flight Time (s)	0.52±0.04	0.36	0.6	0.24
20kg Vertical Jump Height (m)	0.33±0.05	0.16	0.45	0.29
Percent Fall Off	25.35±5.81	9.19	50.55	41.36
Waist to Height Ratio	0.47±0.03	0.41	0.59	0.18

The following statement's statistical data can be viewed in the Table 2. Team three finished in first place out of 55 teams. Team three is statistically different from team four, seven, eight, nine, 11, 12, and 13 in age. There is no statistical difference between team three and remaining teams for height although team three's mean height is taller that the other teams by at least 2 centimeters. Mass is not statistically significantly different between team three and remaining teams although, team three was the second heaviest team. Waist circumference was not statistically significantly different between teams. Push-ups score was statistically significantly different between team three and team seven. Sit-up score was not statistically different between team three and remaining teams. Run score was statistically different between team three and team seven. Total score was statistically significantly different between team three and team seven. There were no significant differences between team three and remaining teams in CMJ flight time or height or percent fall off or waist to height ratio.

Table 3.2 Age Mean±SD, Statistical Significance, and Effect Size

Descriptive Statistics by Team and Event, Statistical Significance, 95% Confidence Intervals, and Cohen's d Effect Size Estimate

	Team	Mean±SD	Statistical Significance	Lower Bound	Upper Bound	Cohen's d
Age	3.00	23.33±2.45				
	1.00	21.00±1.80	.166	-0.27	4.94	1.08
	2.00	23.67±1.32	1.000	-2.94	2.27	-0.17
	4.00	20.00±1.5	.001**	0.73	5.94	1.64
	5.00	22.44±2.4	1.000	-1.72	3.50	0.37
	6.00	21.11±1.17	.263	-0.38	4.83	1.16
	7.00	20.11±0.78	.002*	0.62	5.83	1.77
	8.00	20.22±1.2	.004*	0.50	5.72	1.61
	9.00	20.67±1.22	.038*	0.06	5.27	1.38
	10.00	21.11±1.83	.263	-0.38	4.83	1.03
	11.00	20.67±1.22	.038*	0.06	5.27	1.38
	12.00	20.00±1.41	.001*	0.73	5.94	1.67
	13.00	20.44±1.13	.013*	0.28	5.50	1.51

* indicates statistical significance at $p \leq 0.05$, ** indicates statistical significance as $p \leq 0.001$. Cohen's d Classification: 0.3-0.49, Small Effect; 0.5-0.79, Moderate Effect; 0.8 or Greater, Large Effect

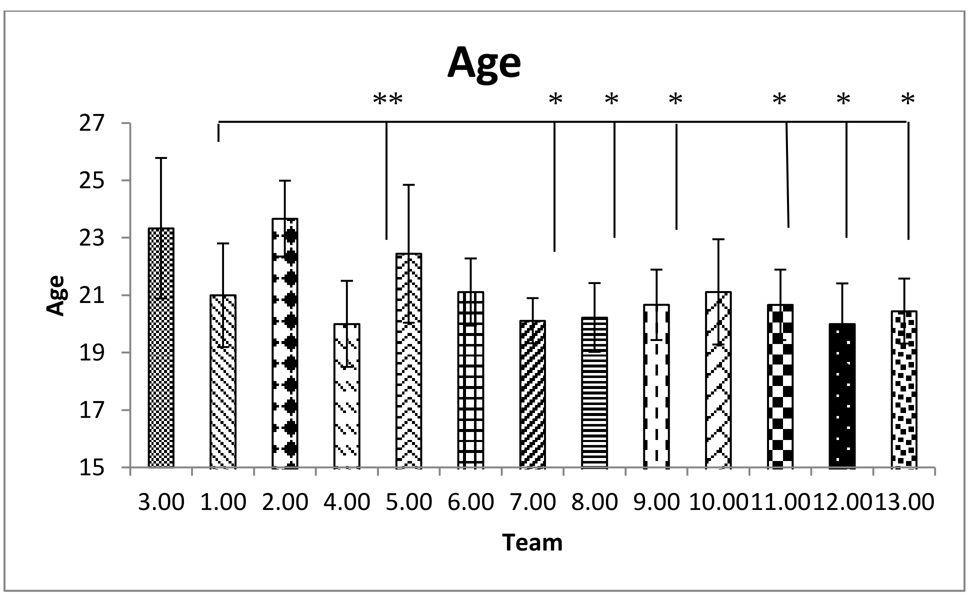

Figure 3.1. Differences in age between team three and remaining teams. ** indicates statistically significant difference at p ≤ .01, * indicates statistically significant difference at p ≤ .05

Table 3.3 Identification of Statistical Significance between team three and all other teams

Descriptive Statistics by Team and Event, Statistical Significance, 95% Confidence Intervals, and Cohen's d Effect Size Estimate

	Team	Mean	Statistical Significance	Lower Bound	Upper Bound	Cohen's d
Push-up Score	3.00	99.89±0.33				
	7.00	79.67±5.83	.000**	14.25	26.19	4.90
Run Score	3.00	98.22±3.19				
	7.00	65.44±12.66	.000**	24.08	41.48	3.55
Total Score	3.00	295.44±5.48				
	7.00	238.00±19.75	.000**	41.69	73.20	3.96

* indicates statistical significance at p≤0.05, ** indicates statistical significance as p≤0.001

DISCUSSION

This study is quite unique due to the type of competition being performed and because the analysis identifies team characteristics. Most studies identify individual characteristics and their implications for individual or team performance (Artioli et al., 2009; Carlock et al., 2004; Hodgdon, 1992; Rayson et al., 2000; Yoon, 2002). During military operations a soldier will seldom ever perform a task on their own. Therefore, it is appropriate to analyze team characteristics and how they may affect team performance on military tasks.

Age

The differences seen between teams are greatest for mean age. The winning team had the second oldest mean age. The Cohen’s d effect size between the winning team and most teams is large (Cohen's d > 0.8 = large effect). The two remaining teams that do not have a large effect size, Team 2 and Team 5 placed 10th and 7th in the competition, respectively. Most cadets begin their ROTC career at the age of 18 when they enter college. The disparity between a mean age of 23 and 21 is the difference between five and three years of ROTC training. Although, training age was not evaluated the authors believe that time spent performing military tasks drastically affects team performance. Research evaluating differences between novice, sub-elite, and elite athletes suggest that age may differentiate between each level of competition (Gabbett, 2009; T. Gabbett et al., 2009).

Anthropometrics, Body Composition, and Countermovement Jumps

Height, body mass, waist circumference, waist to height ratio, CMJs, and percent fall off (strength) showed no statistically significant differences between the winning team and remaining teams. Although, a review of the literature did not reveal team's physical characteristics compared to team performance there is a litany of research suggesting individual characteristics are related to individual performances (Behm, Wahl, Button, Power, and Anderson, 2005; Bos, Mol, Visser, and Frings-Dresen, 2004; Carlock et al., 2004; Davis, Dotson, and Santa Maria, 1981; Grant, Craig, Wilson, and Aitchison, 1997; Henry, William, Michele, Howard, and Wang, 1999; Hoffman, Tenenbaum, Maresh, and Kraemer, 1996; Hudgins, Scharfenberg, Triplett, and McBride, 2013; McBride et al., 2009; Mello, Murphy, and Vogel, 1988; Parchmann and McBride, 2011; Rayson, Holliman, and Belyavin, 2000; Stone et al., 2003, 2005; Williford, Duey, Olson, Howard, and Wang, 1999; Wisløff, Castagna, Helgerud, Jones, and Hoff, 2004).

Body mass has shown strong positive correlations to loaded foot marches, especially as the load increases (Rayson et al., 2000). Body composition (percent body fat, lean mass, and fat mass) has been suggested to effect the performance of distance runners (Arrese and Ostáriz, 2006), martial arts athletes (Franchini et al., 2011; Kazemi, Waalen, Morgan, and White, 2006; Yoon, 2002), and soldiers (Crawford et al., 2011; Marriott and Grumstrup-Scott, 1992; Rayson et al., 2000).

Vertical jump height has been suggested to effect weightlifting performance (Carlock et al., 2004), sprint ability (Sleivert and Taingahue, 2004), playing time in basketball players (Hoffman et al., 1996), and separate starters from non-starters among football players (Young et al., 2005). Maximal strength, as represented by percent fall off, has been suggested to effect vertical jump (Kraska et al., 2009) may also effect weightlifting performance (Stone et al., 2005), sprint ability (Kraska et al., 2009; McBride et al., 2009; Wisløff et al., 2004), and hockey speed skating (Behm et al., 2005; Hoff, Kemi, Helgerud, and others, 2005). This literature suggests that as soldiers improve their body composition, strength, and vertical jump abilities performance on military tasks should improve. Speculating from the previous research that the highest performing team would have high vertical jump heights and high levels of maximal strength (low percent fall off) in comparison to their peers.

In this study no differences were found between the best team and the remaining teams for most variables although; there may be a couple of reasons why: the teams are homogenous because of their training state and the teams are a product of their training programs which tend to be rather homogenous.

Cadets that comprise the team mean are a product of their training program. Meaning, military physical fitness training creates a homogenous group with similar physical characteristics. For example: Elite distance runners have very similar anthropometrics because specific characteristics are beneficial to their sport; narrow hips (Anderson, 1996; Williams, Cavanagh, and Ziff, 1987), slim limbs (Kong and De Heer, 2008), and a low percent body fat (Arrese and Ostáriz, 2006) are all characteristics of elite distance runners. The cadets at the Sandhurst event are the elite of their respective ROTC program which, suggests that these cadets should have similar characteristics. Therefore, statistical differences may not be present unless a team of cadets is relatively unfit. Reserve Officer Training Corps cadets may be similar in body mass and waist circumference at least partly, because of their physical fitness training program.

The physical fitness training program not only develops similar physical characteristics but also dictates the performance characteristics. Cadets participate in physical fitness training on a weekly basis. Strength training as dictated by the TC 3-22.20 states, “Calisthenics are the foundation of Army strength training ...” (Department of the Army, 2010 pg. 2-4). Calisthenics have been suggested to limit strength and power gains because they cannot be overloaded to provide a new stimulus for adaptation (Harman et al., 2008). Intuitively, without a weight training based strength program there should be only small variations in strength and power between teams. The current results depict small variations in strength and power between teams.

Physical Fitness Test

The raw numbers may provide some value if all teams performed the same PFT. Due to the PFT of other military branches and countries comparison of raw numbers could not be made. Accepting the assumption that cadets that perform well in one branch or countries PFT, will score well on the Army PFT allows for comparison of PFT scores. The PFT scores did not provide statistical differences between teams that would explain the success of team three.

Summary

The data suggests that future teams should aim to increase the mean age or increase tactical/technical training for cadets to maximize the age or experience effects. Teams should also select team members that score well on their respective PFT.

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CHAPTER 4

STUDY III

IDENTIFICATION OF DIFFERENCES BETWEEN TOP AND BOTTOM THREE PERFORMING TEAMS ON EACH EVENT OF THE SANDHURST COMPETITION

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ABSTRACT

The purpose of this investigation was to evaluate the physical and performance characteristics of the top three and bottom three performing teams during the Sandhurst Competition. Teams competed in a simulated 2 day military operation where each event was objectively scored. Thirteen teams participated in the study out of 55 competing teams. Each team consisted of nine participants; eight male and one female. Statistically significant differences between top and bottom performing teams were found for each event of the Sandhurst Competition. The results suggest that different physical and performance characteristics may differentiate between successful and less successful teams. Culminations of the results suggest that age/experience may have the greatest effect on military task performance followed by PFT total score. The results of this investigation cannot be extrapolated to the active duty population because the loads carried during the Sandhurst Competition did not match typical loads of combat soldiers.

Key Words: *military fitness, Army physical fitness test,*

INTRODUCTION

Attempts to evaluate physiological characteristics that are necessary for soldier performance are numerous. Proper determination of physiological characteristics necessary for soldier performance is vitally important due to the fact that loss of life is the potential consequence for not possessing the appropriate physiological characteristics. Researchers have evaluated physical fitness changes from pre to post deployment in an attempt to provide an indication of the demands of combat operations (Lester et al., 2010; Sharp et al., 2008). The fatigue effects of sustained field operations have been evaluated to determine decrements in physiological characteristics which may provide indication of muscles used to conduct military tasks (Knapik et al., 1990). Researchers have also evaluated relationships between physiological characteristics and foot marching (Rayson et al., 2000) and ability to lift and carry objects (Hodgdon, 1992; Rayson et al., 2000). Researches have asked Navy SEALS about their perceptions of physical demands of combat operations (Prusaczyk et al., 1995). Even with all of these attempts to identify physiological characteristics there is still a discrepancy as to which characteristics are most important.

There are two studies that reported at pre and post-deployment changes in physiological characteristics. Sharp et al., (2008) evaluated 135 soldiers from an infantry unit of the 10th Mountain Division. Soldiers were evaluated for height, body composition (DEXA), lifting strength, (incremental lifting machine), lower body power, (counter movement jump - Vertec™), upper body power (medicine ball push pass), and VO_2. After a nine month deployment to Afghanistan the researchers found peak VO_2, upper body power, body mass and fat-free mass decreased. Strength and vertical jump performance did not change. In another study, Lester et al., (2010), evaluated73 combat arms soldiers for body composition (DEXA), 1RM bench press and squat, bench throw and squat jump, and 2-mile run. After a 13-month deployment upper and lower body strength, upper body power, lean mass and 2-mile run time increased. The results of these two studies suggest that strength may be a physical characteristics necessary of combat operations as strength did not change (Sharp et al., 2008) or increased (Lester et al., 2010) post deployment. Aerobic fitness may not be as important as strength since in both studies aerobic fitness decreased.

A study of similar design evaluated soldiers before and after a five day simulated combat exercise. The authors interpreted the changes in test performance as fatigue to the musculature indicating specific muscles and energy systems that were used during the simulated combat exercise. Thirty-four male infantry soldiers were evaluated for VO_2 peak, Army Physical Fitness Test (APFT) performance, upper and lower body anaerobic power, and isometric and isokinetic strength of the elbow flexors and knee extensors (Knapik et al., 1990). There was a statistically significant decrease in upper body strength and anaerobic capacity, APFT measures, and one knee extension variable although, all post-testing knee extension values were lower than pre-testing values (Knapik et al., 1990). The results also indicate an increase in lower body peak power which is unique because knee extension values decreased. This may be an effect of familiarization to the study protocol as no mention was made of subject familiarization to the test. The authors conclude that upper body strength and anaerobic power are important to combat operations (Knapik et al., 1990). Due to the lack of familiarization, results of this study suggest that a five day simulated field exercise is systemically fatiguing as almost all variables decreased.

Hodgdon, (1992) evaluated materials handling tasks maximum box lift weight and box carry power to measures of the Navy physical fitness test (2 minutes push-ups and sit-ups and one and a half mile run) and body composition. The results suggest that fat-free mass is the best indicator of maximum box lift weight (r= 0.84), and one and a half mile run was the best indicator of box carry power (r= -0.67) (Hodgdon, 1992). It needs to be mentioned that the box carry power tasks was 10 minutes in duration (very similar to the one and a half mile run test) although, the correlation between box carry power and fat-free mass was strong (r= 0.44) (Hodgdon, 1992). In another study of British soldiers Rayson et al., (2000) identified single lift ability, repetitive lift and carry ability, and loaded foot marching as important tasks of infantry soldiers. The single lift ability, repetitive lift and carry ability, and loaded foot marching were statistically significantly correlated to fat-free mass, upper body muscular endurance, and multi-stage fitness test (beep test), respectively (Rayson et al., 2000). The combination of these two studies suggests that fat-free mass and aerobic fitness is important to successful completion of military tasks.

An evaluation of Navy SEALs mission essential physiological characteristics suggests aerobic fitness is more important that strength. Prusaczyk et al., (1995) evaluated 82 SEALs and their perceptions of importance of physiological characteristics to mission success. Navy SEALs reported that 93 % of the time aerobic endurance was the primary fitness component and strength was a secondary component. Of the secondary fitness components lower limb strength was most important followed by back and arm/shoulder strength (Prusaczyk et al., 1995). Even though this study may place greater emphasis on aerobic fitness there is still strong indication that strength is also important.

Through the evaluation of physiological characteristics that may be important for combat operations or mission essential tasks there is a trend that aerobic fitness, muscular strength, and fat-free mass are important for individual soldiers. This is vital information although, soldiers rarely, if ever, perform military operations independently. A thorough evaluation of the literature revealed no research that evaluates team physical characteristics to team performance on simulated combat operation skills or tasks. The purpose of this study is to evaluate differences between physical and physiological characteristics of the top three most successful teams on each event of the Sandhurst Competition to the characteristics of the lowest three performing teams.

METHODOLOGY

Participants

Participants will consist of 117 cadets from ROTC units all over the world. These 117 participants made up 13 teams that competed in the Sandhurst Competition. There are nine cadets in each team; eight male cadets and one female cadet. Each team's data will be averaged to represent their respective team.

Testing

Height.

Height was assessed using a metric tape that will be attached to the wall. Height was assessed to the nearest 0.5 cm. Shoes were removed with heels touching each other and against the wall. Participants were instructed to stand tall with head and eyes looking forward.

Body Mass.

Mass was assessed with the participant wearing shorts and t-shirt for males and females. Mass was measured to the nearest 0.1 kg on a balance scale (Detecto-Medic, Brooklyn, NY).

Waist Circumference.

Waist circumference was assessed using a metric fabric tape measure. Measurements were taken at the umbilicus with the participants arms at their side. Measurements were recorded to the nearest half centimeter.

Waist to Height Ratio.

Waist to height ratio is an evaluation used to determine health risks. Waist to height ratio was calculated as follows:

Waist to Height Ratio = Waist circumference (cm) / Height (cm)

Standard Warm up Protocol for Vertical Jump Evaluation

Participants performed a standard warm-up protocol prior to vertical jump evaluations. The warm up consisted of 25 jumping jacks followed by one 75 % effort jump unloaded (0 kg) and one jump with maximal effort unloaded (0 kg). Between the unloaded and loaded (20 kg) condition, one loaded jump at 75 % effort was performed for familiarization prior to maximal effort loaded (20 kg) jumps.

Vertical Jump Protocol.

After the standard warm up the cadets started the vertical jump protocol that includes countermovement jumps (CMJ) with 0 kg (PVC pipe) or 20 kg (empty weightlifting bar) loads. The cadets were instructed to put the PVC pipe across their back at the thoracic vertebrae 1 level ("Put the bar across your back as if you were going to do a squat"). The cadet's hands were placed on the bar to limit the use of any arm swing that may potentially increase jump height. This was the bar and hand placement for all vertical jump conditions.

Prior to the start of a new jump, one familiarization/warm up trial was conducted at 75 % of max effort. Cadets are then familiarized to the series of commands for vertical jump evaluation. The commands are as follows: Step on the mat, hold still, and then a countdown of "3, 2, 1, jump" followed. On the command "jump" the cadet jumped with 75 % effort (warm up) or maximal effort (data collection) depending upon the situation. Each cadet performed a minimum of three maximal jumps at each condition, with each weight. All jumps were averaged and used for data analysis. Requisition for an additional attempt would include jumping without their heels being in contact with the mat, jumping forward, or lack of effort perceived by the clinician or cadet (indicated by greater than 5 cm difference). Data from all jumps were measured with a switch mat (Just Jump Systems, Huntsville, AL). This protocol is very similar to that used by Kraska et al., (2009). Flight time was recorded for each jump. Flight time was then used to calculate vertical jump height from the formula:

Vertical jump height = (g X flight time X flight time)/8 (Jon M. Carlock et al., 2004)

Strength.

Unloaded (0kg) countermovement jump can be used as an assessment of lower body power (Everett A. Harman, Rosenstein, Frykman, Rosenstein, and Kraemer, 1991). The loaded (20kg) countermovement jump may be considered an estimate of strength and power (Kraska 2009). Kraska et al. (2009) found strong relationships between force characteristics and vertical jump height. Additionally, they (Kraska et al. 2009) showed that stronger athletes had less fall-off in vertical jump height and power as the jump-load increased. Furthermore, in an assessment 124 athletes and cadets there was a strong relationship between isometric peak force and percent fall off from 0-20 kg jump height (r= 0.55 CMJ and r= 0.52 SJ) (unpublished data from our lab).

Thus, if the loaded countermovement jump height is subtracted from the unloaded countermovement jump height, the result can be interpreted as an estimate of relative strength (Kraska et al. 2009). The calculation used for determining strength is:

Percent Fall Off = Unloaded CMJH (0 kg) - Loaded CMJH (20 kg) / Unloaded CMJH (0 kg) x 100

Physical Fitness Test.

ROTC leaders from each team reported the most recent PFT scores for all of the participants. Physical fitness tests were conducted within two months prior to the competition. The PFTs were conducted within the guidelines provided by the TC 3-22.20 (Department of the Army, 2010) or respective physical fitness testing doctrine.

Assumptions

There are several different military branches that comprise the participants of the study. It is well know that each military branch has a slightly different physical fitness test but include the activities of push-ups, sit-ups, and running. Therefore, the researchers assumed that a cadet that scores well on their respective military branch PFT would also score well on another military branch PFT since the events are similar.

Limitations

A limitation of the study results from cadets scoring the maximal number of push-ups, sit-ups or running a maximum scoring time. First, cadets are discouraged from doing more than the maximum because it does not relate to more points on the PTF. Second, most cadets participating in this event are the best at their respective unit/university and therefore score very close to the maximum points on the PFT. With all of the high scores identifying meaningful relationships between characteristics becomes difficult.

The Sandhurst Competition 2013

Marksmanship

Situation. A Platoon sized Enemy element (approximately 20-25 insurgents) is suspected to be moving dismounted through AO SANDHURST with the intentions of crossing New York State (NYS) Route 293. The latest imagery shows the enemy Platoon moving through an open area dispersed to reduce their signature using local national farmers as guides to transit the AO. The insurgents are armed with AK47s. They are dressed in dark green military style clothing and the local farmers traditionally wear white clothing.

Mission. On order, your Squad defends the Battle Position (BP) at Range 5 against dismounted enemy personnel in order to prevent them from crossing NYS Route 293.

Key Tasks. Occupy battle position and establish hasty defense. Minimize collateral damage to the local population as they are believed to be intermixed with insurgent forces in the open area wearing white shirts. Utilize existing cover and concealed positions to defend Battle Position 1. Effects of your weapon systems will not enter adjacent platoon's battle space as they have established blocking positions to your left and right in order to prevent enemy reinforcements from influencing your position.

Execution and Constraints. Your Squad has 5 minutes to plan and be prepared to move to your link up point (at the command of the Briefing Area personnel). You will move dismounted to the link up point where you must occupy the BP immediately upon receiving your ammunition. Move straight from the link up point to the BP and behind cover. You will stow your ammunition on your person and only load your weapon when in the BP. You may move laterally within the BP, however you are not authorized to move forward of the firing line. You will hear an air horn blow at the BP when you are mission complete. Once mission complete you will lock and clear your weapons, safely move to the range tower with all of your magazines and remaining live ammunition to be counted by range personnel. The number of rounds you have remaining will be used in the event of a tie (reward for accuracy). Once cleared by range personnel at the range tower, you will immediately move off the range and toward your next check point (your time is still running). No loitering, remember you are on the clock at all times!

Safety Violations. Muzzle Awareness – Cadet is aware what is in front of, behind, and to the flanks of his / her target (example – individual ensures muzzle clears debris within BP prior to engaging targets).You will move dismounted to the link up point where you must occupy the BP immediately upon receiving your ammunition. Move straight from the link up point to the BP and behind cover. Weapon Orientation – Cadet maintains a safe orientation of his / her weapon system while engaging targets and moving within the BP (i.e. does not flag others). Weapon Status (Mechanical Safety) – Weapon remains on safe unless Cadet is actively engaging targets. Magazines are loaded and round is chambered only when Team has occupied BP (inserting a magazine into the magazine well prior to occupying the BP will result in automatic disqualification from the Sandhurst Marksmanship Competition). Weapons are placed on safe prior to any lateral movement within the BP. Hand Position – Finger remains outside of the trigger well until Cadet is actively engaging targets. Personal Protective Equipment (PPE) – All Cadets will wear the following PPE: ballistic helmet, eye protection, hearing protection, and load bearing equipment (gloves are optional). Additional Safety Information – Any act that a Range Safety deems as unsafe (and is not listed above) may result in a warning and / or penalty.

Penalties. Safety Violation (after initial warning) -20 points

Shooting a non-combatant -10 points

Loading a magazine prior to occupying the BP Disqualification.

Rope Bridge

Situation. You have encountered a water gap crossing on your movement to the objective.

Mission. On order as quickly as you can, using onsite equipment and your Squad, construct a rope bridge across the water obstacle in order to safely continue onto your objective.

Constraints.

- You have no more than 7 minutes to complete this lane on the command of "go".
- The rope bridge must be clear of the water, allowing a crossing without contact with the water.
- Only one person attached to the bridge at any one time.
- Only the first and last squad member may enter the gap/water while the bridge is anchored at one point. They must be attached to the bridge or a safety line whilst conducting the transit. These members must not transport the burden.
- Two anchor points must be established (one on the far side with at least 4 wraps and one on the near side).
- All equipment utilized will be recovered to the far bank.

- The rope bridge must be fully disassembled and recovered.
- The time of the rope bridge starts once the squad has assembled the Swiss Seats correctly and is given the words of command "GO".

The team who crosses the gap with all of the equipment that they utilized in the fastest time (after subtraction of time penalties) wins the event.

Penalties.

• Loss of equipment in transit	+ 30 seconds each
• More than one person crossing at any one time	+ 5 minutes each
• Burden not transported across river (mission failure)	+ 5 minutes
• Far side anchor does not have 4 wraps of rope around the tree	+ 3 minutes
• Burden transported across by the first and/or last squad member	+ 7 minutes

- Improper Swiss Seat (Individual is held until deficiency is correct at the staging area)
- Personnel/Equipment who contact the water will start again from the home bank

Pistol Site

Timeline. You have 90 seconds for your team to read and organize for this mission.

Uniform. Eye and Ear Protection, Helmet and Load Bearing Equipment. Rifles must be slung across the back of all team members.

Situation. You are supporting a military police (MP) unit who is in danger of being overrun. All of your 5.56mm ammunition was spent in the defensive position you just departed. The MPs have left you M9 pistols and ammunition.

Mission. Immediately occupy your firing positions, secure and load your pistols, and on the command *"Watch and Shoot, Watch and Shoot,"* the lane will begin. Engage targets as they appear.

Execution and Constraints.

- Your team must be organized into seven firers and one weapons assembly person; squad leader must supervise everyone. The seven firers will cover down on a lane numbered 1 to 7 upon occupation of the site. Each firing point will have an M9 pistol and four magazines of seven rounds each prepositioned. The location of the each firing lane is denoted by a numbered sign while the actual firing point is denoted by a red dot just forward of the numbered signs on the path. Each lane's targets are color coded to that lane. Enemy targets will either be all green or all tan based on lane number. White targets denote civilians. Any shooting of a civilian target will carry a five point penalty for each hit.
- Pistol assembly will begin when the designated weapons assembly team member first touches any pistol component and concludes when the team member sets down the final assembled weapon. The team member must then execute an untimed function check on each pistol to verify to the grader that assembly was properly completed.

- On the Command *"Lock and Clear, Lock and Clear,"* the scenario is finished. Lock and clear your pistol, a range safety will inspect it, and then place the pistol back where you found it. Finally, move to the base of the tower for follow on instructions.

Penalties.

• Unsafe handling of pistol (flagging, dropping etc.)	-10 Points from lane score
• Any missing uniform item	-5 Points per incident
• Improper pistol assembly	-10 Points per occurrence

Start Point and End Point

Situation. Sandhurst competitors must undergo a Start Point and End Point equipment inspection on both days of the Sandhurst competition.

Mission. Teams will report to the Start Point at IVO MacArthur Statue and the Superintendent's House (WL87108280) at their prescribed starting time and undergo a comprehensive equipment inspection before starting. All deficiencies will be identified and annotated on the team's scorecard. Following the equipment inspection each team will clock out at the E-Punch station and navigate to the next event within the Sandhurst competition. Each team's time will be stopped when they report back to the E-Punch station following each day's events. The teams will once again undergo a comprehensive equipment inspection and all deficiencies will be identified and annotated on the team's scorecard.

Execution and Constraints.

- You must arrive at the Start Point / End Point with all your team members and all squad equipment in order to start and end each day of the competition.
- Teams are not authorized to possess personal global positioning systems, cell phones / phones and unissued maps.
- Assigned Start Point End Point staff will escort each team thru the node.
- Teams must ensure they E-Punch their team’s scorecard before departing and upon returning to the Start Point / End Point (on each day of the competition).

Penalties.

• Missing or unserviceable equipment	+30 sec each item
• Squad members not reflected on Squad roster	Disqualification
• Unapproved departure or interaction within the SP/EP	+30 min/and or disqualification
• No female Squad members	Disqualification
• Possession of unauthorized equipment	Disqualification
• Missing Squad members	Disqualification

DMI Challenge Lane

Situation. You must prepare your personnel for water operations and ensure they can efficiently move a zodiac boat for follow-on missions. However, you must cross a minefield to reach your boat.

Mission. PHASE 1: Move to your assigned lane on Daly Field by following the white engineer tape up the hill. Upon arrival to your lane, use the given equipment to move all team members and personal equipment across the minefield without any personnel/items touching the ground. Successfully move everyone across in 5 minutes and you will have a lighter boat for Phase 2. If the entire team does not cross the minefield in 5 minutes, you will be told to cease work and move to Phase 2. The penalty will be a heavier boat to carry. You may not skip this phase. PHASE 2: Move the Zodiac boat with all team equipment around the specified course which is marked by personnel in orange road guard vests. Any additional burdens in the boat will be determined by your performance during Phase 1. Final score is determined by overall time (plus penalties) which starts when you reach your lane on Daly Field and stops when Zodiac course is complete and equipment has been moved back to the exact spot where you picked it up.

Execution and Constraints.

- Team members/equipment may not touch the ground in the minefield
- The Zodiac boat must be carried. No Dragging
- Teams are not allowed to pour any water out of the water cans
- Personnel in orange road guard vests will tell you where to turn on the course
- Teams must follow the designated route

- Upon completion of the course, drop Zodiac and all burdens back in the exact spot where they were picked up

Penalties.

• Team takes longer than 4 minutes to reach Daly Field	+ 5 min
• Personnel/equipment touches ground in the minefield	+ 2 min (ea. occurrence)
• Dragging Boat	+ 5 min (ea. occurrence)
• Failure to move personal equipment/burdens on route	+ 5 min (ea. item)
• Purposely blocking the path of a faster team	+ 10 min (ea. occurrence)
• Moving off of designated route	+ 15 min (ea. occurrence)
• Water poured from water cans	Disqualification
• Skipping any phase	Disqualification
• Zodiac boat damaged	Disqualification

Land Navigation

Situation. You are at the Land Navigation site in the pre-event lane, which consists of three stations. Your time at each station is three minutes. When you hear the next whistle blast, proceed from the Map and Equipment Issue Station to the Water Resupply Station.

Mission. Your squad is allotted *120 minutes (2 hours)* of land navigation course time to locate up *to forty (40)* land navigation points using no more than two (2) cadre-issued P-cards and two (2) cadre-issued West Point Land Navigation Special, WGS-84 maps both of 1:10,000 (1:10K) scale. This is not a self-correcting course. Each P-card can only receive credit for a maximum of twenty (20) points.

Execution and Constraints.

- You may negotiate the course in 2 separate teams however each team must have at least 4 personnel.
- Each Land Navigation control point recorded on your P-card is worth one point.
- There are dummy control points on the course that DO NOT count towards your overall score, accurate navigation is essential.
- Control points on the course are only available during specific times – take note of the activation times listed for each point on your map (i.e. you must find the right point at the right time) – control points not found during this activation time window DO NOT count towards your final score.
- You may use only the cadre-issued maps!

Penalties.

• Unaccounted for personnel or equipment	Squad disqualification
• Unauthorized map use	Squad disqualification
• Collaboration with other Sandhurst teams	Squad disqualification
• Use of any type of non-issued GPS system	Squad disqualification
• Travelling in elements smaller than four per team	Squad disqualification
• Movement outside of course boundaries	Squad disqualification

- Exceeding course execution time of 120 minutes -5 points assessed for each minute late

- Loitering at start or finish point (exceeds assigned prep times) -1 point assessed for each 30 seconds

Hand Grenade

Situation. There are 5-7 enemy dismounts in the area manning 2 fortified bunkers and buildings. They have been observed with AK-47s and RPGs. Also, known enemy snipers are engaging friendly forces from the windows on the local buildings.

Mission. On orders, your squad (divided into 3, 3 man teams) approaches the three enemy positions. Conduct this movement in a concealed manner and engage with hand grenades in order to destroy the enemy.

Execution and Constraints.

- You must negotiate the course with your team, personal equipment, and weapon (ACH, eye pro, and gloves must be worn throughout the course). Secure 3 hand grenades for each member of your team and move out to your assigned lane.

- At your assigned lane identify your 3 targets. High crawl to your targets and maintain a low profile throughout the entire course. 1 hand grenade per person, per target.

- Each member of the team will engage 3 targets. You will throw from the back, kneeling and standing positions. After each member engages the target, each team of 3 will continue to rotate until all targets have been attempted. Only rotate when each team of 3 is ready. Once complete you and your team sprint to the check-out table.

Penalties.

- Unsafe handling of the hand grenade. Hand grenade detonates in the hand or on the ground in vicinity of soldier and team members Disqualification for that individual
- Exposure from covered position for more than 3 seconds -5 points each occurrence
- Soldier takes more than 15 seconds to prep and throw hand grenade -5 points

Incentives.

- Soldier scores 30 points +5 points
- Speed and overall score will determine the Hand Grenade winner!

Vertical Obstacle "The Wall"

Situation. Enroute back to your patrol base you encounter a wall obstacle.

Mission. On order your squad is to move over the wall and continue along your route.

Execution and Constraints.

- Time for the event begins once the first member of the squad enters the mulch pit and stops once all personnel and assigned equipment have safely cleared the wall and exits the pit.
- At no time can you have more than three Soldiers on the top of the wall.
- Positive control of equipment will be maintained at all times.
- Site safeties will stop any unsafe act or unsafe method of moving over the wall.

- Squad Leader will be blindfolded.
- Only black parts of the wall are authorized to be used. Red areas are off limits.
- No more than 5 minutes will be allowed to attempt to negotiate the wall.

Penalties.

• More than 3 Soldiers on top of the wall at any given time	+30 sec each occurrence
• Loss of control of equipment (dropping, throwing it, etc)	+30 sec each occurrence
• Any unsafe act determined by wall safety officer	+30 sec each occurrence
• Moving over the wall in an unauthorized location	+30 sec each occurrence
• Failure to complete event (5 minutes elapsed)	zero points awarded

CBRN and Weapons Assembly

Situation. This lane will begin in two minutes. You have encountered a chemically contaminated environment. Prepare to conduct operations in a degraded environment. Ensure that all equipment is accounted for prior to executing this lane.

Mission. At the command of "GAS, GAS, GAS", be prepared to don your chemical protective mask. Once donned, do not remove your mask until instructed to do so. When you hear "STOP", cease all work and place your hands at your sides. Team members will then by instructed by the cadre to demonstrate that their mask is sealed.

Leave your mask on! Once instructed to do so by the cadre, move forward to the table and take instructions from your squad leader for weapons assembly. Once you have assembled all 5 weapon systems and performed a functions check, place all five weapons on the table and step back.

Execution and Constraints.

- You must negotiate this site with all team members and all personal equipment.
- Do not remove your mask until told to do so by cadre.
- All masks sealed within 9 seconds results in 100 points.
- Keep positive control of all pieces of each weapon system during assembly.
- Assemble all 5 weapon systems/conduct functions check in no more than 5 minutes; this will result in 100 points.

Penalties.

• Squad leader fails to achieve mask seal in 9 seconds	(-12 points)
• Squad member (each) fails to achieve mask seal in 9 seconds	(-11 points)
• Any piece of equipment on the ground at the 9 second mark	(-1 point per item)
• Removing a mask prior to being told to do so by cadre	(-20 points)
• Team Member fails to complete course	(-20 points)
• Team Member arrives without mask/cannot execute lane	(-20 points)
• Failure to properly assemble the M240B machine gun	(-30 points)
• Failure to properly assemble the M249 machine gun	(-25 points)
• Failure to properly assemble the M4 carbine	(-20 points)

- Failure to properly assemble the AK-47 (-15 Points)
- Failure to properly assemble the M9 pistol (-10 points)
- Losing any part of a weapon system Disqualification

Reconnaissance

Reconnaissance Patrol Debrief: Answer each question based on your patrol's observations. Turn in this debrief before you reach the finish line.

1. What small arms weapon systems does the enemy possess?

____

____

2. Does the enemy have armored vehicles? If so, what type and capabilities do they have?

____

____

____

____

3. What helicopters does the enemy have?

____

____

____

4. What fixed wing fighters does the enemy have?

____

5. Does the enemy have indirect fire systems? If so, what type and capabilities do they have?

____

6. Is there evidence of enemy naval activity on the major waterways along your route?

____

Statistical Analysis

A Multivariate ANOVA was performed to identify difference between the highest performing three teams compared to the lowest performing three teams for each event. Post hoc analysis included a Bonferonni adjustment and calculation of Partial Eta² measure of effect size. Secondary and tertiary analyses were done to remove outlier data and female data.

The initial analysis provided results that were vastly different from the literature. The initial analysis suggested that push-ups score, run score, total score, and age were the primary indicators of performing well on the Sandhurst Competition. A second look at the data revealed that team seven was an outlier and had significantly lower physical fitness scores (refer to article two) than the other participating teams. This influenced the results of the analysis identifying differences between top and bottom three teams, if team seven was in either top or bottom group.

A third analysis was done that removed the female competitors from the data set. Females on average have a greater body fat percentage, less total mass, less muscle mass, more fat mass, are shorter, and as a result may not jump as high as male ROTC counterparts. There were nine participants on each team and one had to be female. The lone female on each team constitutes 11 % of the team data. Due to the differences between sexes, standard deviations were larger than if the team were comprised of just males. Analysis of the data after the outlier team and female data were removed show statistically significant differences for PFT scores, age, CMJs, and percent fall off.

RESULTS

Table 4.1 Descriptive Statistics of both Top and Bottom Participating Cadets

Descriptive Statistics				
	Mean±SD	Minimum	Maximum	Range
Age (yr)	21.14±1.91	18	28	10

Height (cm)	176.24±8.1	151	195	44
Weight (kg)	78.54±9.24	49.88	104.74	54.86
Waist Circumference (cm)	82.95±5.32	70	100	30
Push-up Score	97.02±6.27	69	100	31
Sit-up Score	97.18±5.6	71	100	29
Run Score	95.76±10.23	53	100	47
Total Score	289.97±18.01	206	300	94
0kg Vertical Jump Flight Time (s)	0.60±0.04	0.5	0.69	0.19
0kg Vertical Jump Height (m)	0.45±0.06	0.3	0.58	0.28
20kg Vertical Jump Flight Time (s)	0.52±0.04	0.36	0.6	0.24
20kg Vertical Jump Height (m)	0.33±0.05	0.16	0.45	0.29
Percent Fall Off	25.35±5.81	9.19	50.55	41.36
Waist to Height Ratio	0.47±0.03	0.41	0.59	0.18

Table 4.2a Means and Standard Deviations, Statistical Significance, and Partial Eta^2 Estimate of Effect Size between Top and Bottom Performing Teams

Descriptive Statistics, Statistical Significance, and Effect Size between High and Low Performing Teams with Outliers and Females Removed for all Events of the Sandhurst Competition

		Rifle Marksmanship			Pistol Marksmanship			Land Navigation		
		Mean±SD	Statistical Significance	Partial Eta^2	Mean±SD	Statistical Significance	Partial Eta^2	Mean±SD	Statistical Significance	Partial Eta^2
Sandhurst Event Points Scored	High Performers	55±2.21	.000**	.924	54±2.21	.000**	.994	48±2.21	.000**	.990
	Low Performers	13.33±8.35			6.67±1.27			6±2.21		
Push-up Score	High Performers	99.37±1.79	.057	.077	97.75±3.21	.391	.016	99.96±.2	.010*	.134
	Low Performers	97.54±4.24			96.61±5.59			96.92±5.58		
Sit-up Score	High Performers	99.04±3.15	0.36*	.092	98.71±2.97	.028*	.101	99.46±2.65	.083	.064
	Low Performers	96.13±5.79			95.30±6.72			97.33±5.25		
Run Score	High Performers	98.83±2.27	.056	.077	99.21±1.82	.049*	.082	99.33±2.08	.040*	.089
	Low Performers	95.8±7.21			96.16±7.16			96.13±7.12		
Total Score	High Performers	297.25±4.6	.001**	.203	295.67±5.82	.008*	.144	298.75±3.42	.002*	.188
	Low Performers	289.47±10.16			288.06±12.03			290.38±12.09		
Age	High Performers	22.67±2.28	.000**	.269	22.67±1.99	.000**	.286	21.8±2.28	.891	.000
	Low Performers	20.42±1.41			20.54±1.38			21.91±1.89		
Height (cm)	High Performers	179.56±6.79	.188	.037	1787.65±8.75	.701	.003	178.67±6.98	.909	.000
	Low Performers	177.03±6.29			177.83±5.65			178.46±5.54		
Mass (kg)	High Performers	81.14±6.87	.997	.000	80.81±8.07	.676	.004	81.08±6.99	.787	.002
	Low Performers	81.15±6.67			79.7±6.75			80.57±5.98		
Waist Circumference (cm)	High Performers	84.08±4.51	.914	.000	85.15±4.71	.086	.063	83.96±4.25	.617	.005
	Low Performers	83.93±5.14			82.63±5.22			83.35±4.06		
0kg CMJ Flight Time (s)	High Performers	.60±.03	.470	.011	.60±.03	.208	.034	.61±.03	.718	.003
	Low Performers	.61±.03			.62±.04			.61±.04		
0kg CMJ Jump Height (m)	High Performers	.45±.04	.383	.017	.45±.05	.188	.037	.46±.05	.608	.006
	Low Performers	.46±.05			.47±.06			.47±.06		
20kg CMJ Flight Time (s)	High Performers	.52±.03	.448	.013	.53±.03	.838	.001	.53±.03	.738	.002
	Low Performers	.53±.03			.53±.04			.54±.04		
20kg CMJ Jump Height (m)	High Performers	.34±.04	.450	.012	.34±.04	.806	.001	.35±.04	.702	.003
	Low Performers	.34±.04			.35±.05			.35±.05		
Percent Fall Off	High Performers	24.72±4.29	.969	.000	22.89±5.03	.035*	.093	24.19±3.77	.739	.002
	Low Performers	24.67±2.63			25.53±3.17			24.57±4.07		
Waist to Height Ratio	High Performers	.47±.03	.489	.010	.47±.03	.185	.038	.47±.03	.673	.004
	Low Performers	.47±.04			.47±.03			.47±.02		

		Grenade Throw			Obstacle Course			CBRN/WPNS		
		Mean±SD	Statistical Significance	Partial Eta^2	Mean±SD	Statistical Significance	Partial Eta^2	Mean±SD	Statistical Significance	Partial Eta^2
Sandhurst Event Points Scored	High Performers	54.33±1.74	.000**	.914	52±5.46	.000**	.910	52±4.41	.000**	.973
	Low Performers	19.33±7.57			14.6746.48			15±.83		
Push-up Score	High Performers	98.97±4.36	.545	.008	99.58±1.44	.101	.057	99.58±1.44	.015*	.121
	Low Performers	98.23±3.11			98.5±2.83			96.61±5.59		
Sit-up Score	High Performers	97.54±5.37	.275	.026	99.25±2.8	.638	.005	99.25±2.8	.011*	.133
	Low Performers	98.92±2.87			98.83±3.28			95.3±6.72		
Run Score	High Performers	98.58±3.16	.405	.015	99.33±2.08	.755	.002	99.33±2.08	.042*	.087
	Low Performers	99.21±1.82			99.5±1.56			96.16±7.16		
Total Score	High Performers	294.92±10.24	.580	.007	298.17±4.02	.356	.019	298.17±4.02	.000**	.249
	Low Performers	296.25±5.69			296.03±5.73			288.07±12.03		
Age	High Performers	20.83±1.43	.032*	.096	22.54±2.38	.002*	.184	22.54±2.38	.001**	.216
	Low Performers	21.92±1.93			20.75±1.33			20.54±1.38		
Height (cm)	High Performers	176.67±6.99	.389	.016	179.06±9.72	.395	.016	179.06±9.72	.592	.006
	Low Performers	178.25±5.5.2			177.16±4.75			177.83±5.65		
Mass (kg)	High Performers	80.24±6.57	.745	.002	82.26±8.48	.066	.072	82.26±8.48	.292	.024
	Low Performers	79.63±6.21			78.37±5.52			79.9±6.75		
Waist Circumference (cm)	High Performers	82.71±4.45	.288	.025	84.94±4.04	.070	.070	84.94±4.04	.093	.060
	Low Performers	84.17±4.93			82.53±4.72			82.63±5.22		
0kg CMJ Flight Time (s)	High Performers	.63±.04	.013*	.126	.62±.03	.063	.073	.62±.03	.967	.000
	Low Performers	.60±.03			.60±.03			.62±.04		
0kg CMJ Jump Height (m)	High Performers	.48±.06	.015*	.123	.47±.05	.073	.068	.47±.05	.911	.000
	Low Performers	.44±.05			.44±.05			.47±.06		
20kg CMJ Flight Time (s)	High Performers	.55±.04	.089	.062	.53±.03	.158	.043	.53±.03	.795	.001
	Low Performers	.53±.03			.52±.03			.53±.04		
20kg CMJ Jump Height (m)	High Performers	.37±.05	.066	.072	.35±.04	.145	.046	.35±.04	.744	.002
	Low Performers	.34±.04			.33±.04			.35±.05		
Percent Fall Off	High Performers	23.85±3.77	.333	.020	24.44±4.05	.724	.003	24.44±4.05	.305	.023
	Low Performers	22.64±4.72			23.92±5.84			25.53±3.17		
Waist to Height Ratio	High Performers	.47±.02	.635	.005	.47±.03	.384	.017	.47±.03	.258	.028
	Low Performers	.47±.03			.47±.03			.47±.03		

** Indicates Statistical Significance at $p \leq 0.001$, * Indicates Statistical Significance at $p \leq 0.05$

Table 4.2b Means and Standard Deviations, Statistical Significance, and Partial Eta² Estimate of Effect Size between Top and Bottom Performing Teams

Descriptive Statistics, Statistical Significance, and Effect Size between High and Low Performing Teams with Outliers and Females Removed for all Events of the Sandhurst Competition

		One Rope Bridge			Vertical Challenge (wall)			Reconnisance			DMI Challenge			Course Time			Overall Place		
		Mean±SD	Statistical Significance	Partial Eta²	Mean±SD	Statistical Significance	Partial Eta²	Mean±SD	Statistical Significance	Partial Eta²	Mean±SD	Statistical Significance	Partial Eta²	Mean±SD	Statistical Significance	Partial Eta²	Mean±SD	Statistical Significance	Partial Eta²
Sandhurst Event (points scored)	High Performers	49±3.01	.000**	.970	50±.83	.000**	.993	52±3.82	.000**	.944	56.33±1.74	.000**	.966	54.33±2.09	.000**	.991	3.33±2.68	.000**	.949
	Low Performers	27.0±0			6.67±2.41			10.67±6.15			13.67±5.55			6.67±2.55			44.33±6.32		
Push-up Score	High Performers	98.33±4.03	.713	.003	99.58±1.44	.184	.038	99.96±.2	.004*	.164	98.48±2.66	.879	.001	99.58±1.44	.267	.027	99.58±1.44	.028*	.101
	Low Performers	98.66±2.65			98.71±2.84			98.05±3.10			98.33±4.03			98.51±4.45			97.12±4.44		
Sit-up Score	High Performers	99.17±2.29	.442	.011	99.25±2.80	.417	.014	98.63±3.75	.776	.002	96.59±5.97	.055	.078	99.25±2.80	.057	.077	99.25±2.80	.164	.042
	Low Performers	98.53±3.52			98.5±3.5			98.33±3.41			99.17±2.29			96.75±5.63			97.88±3.85		
Run Score	High Performers	97.58±7.13	.451	.011	99.33±2.08	.899	.000	98.88±2.80	.590	.006	98.36±2.43	.614	.006	99.33±2.08	.029*	.100	99.33±2.08	.112	.054
	Low Performers	98.64±2.92			99.25±2.44			98.39±3.29			97.58±7.13			97.27±3.96			96.83±7.28		
Total Score	High Performers	295.08±9.91	.732	.002	298.17±4.02	.270	.026	297.46±5.23	.131	.049	293.44±7.10	.513	.009	298.17±4.02	.017*	.117	298.17±4.02	.010*	.135
	Low Performers	295.83±6.37			296.46±6.33			294.78±6.69			295.08±9.91			292.53±10.44			292.13±10.27		
Age	High Performers	21.7±1.96	.017*	.100	22.54±2.37	.003*	.173	21.83±2.24	.546	.008	22.46±2.54	.128	.050	22.54±2.38	.000**	.234	22.54±2.38	.009*	.139
	Low Performers	20.62±1.33			20.83±1.27			21.46±2.02			21.46±1.89			20.50±1.22			21.04±1.27		
Height (cm)	High Performers	177.85±8.18	.428	.012	179.06±9.72	.352	.019	178.69±8.04	.398	.016	180.37±6.95	.160	.042	179.06±9.72	.158	.043	179.06±9.72	.580	.007
	Low Performers	176.36±5.81			176.83±6.38			176.52±9.48			177.31±7.86			175.44±7.66			177.75±6.20		
Mass (kg)	High Performers	81.13±7.33	.306	.019	82.26±8.48	.127	.050	82.26±7.46	.487	.011	82.45±7.36	.126	.050	82.26±8.48	.348	.019	82.26±8.48	.388	.016
	Low Performers	79.28±6.01			78.82±6.76			80.46±8.55			79.19±7.10			80.13±7.01			80.28±7.24		
Waist Circumference (cm)	High Performers	83.98±3.25	.644	.004	84.94±4.04	.004*	.086	83.52±4.48	.245	.029	84.89±5.71	.086	.063	84.94±4.04	.102	.057	84.94±4.04	.047*	.083
	Low Performers	83.46±4.65			82.19±5.07			85.14±4.66			82.56±3.16			82.83±4.69			82.27±4.97		
0kg CMJ Flight Time (s)	High Performers	.62±.03	.005*	.135	.62±.03	.465	.012	.62±.03	.048*	.082	.60±.02	.100	.058	.62±.03	.968	.000	.62±.03	.826	.001
	Low Performers	.60±.03			.61±.03			.60±.04			.62±.03			.62±.04			.62±.03		
0kg CMJ Jump Height (m)	High Performers	.48±.05	.007*	.129	.47±.05	.487	.011	.47±.04	.059	.075	.45±.04	.121	.052	.47±.05	.914	.000	.47±.05	.768	.002
	Low Performers	.44±.05			.46±.05			.45±.05			.47±.05			.47±.05			.47±.05		
20kg CMJ Flight Time (s)	High Performers	.54±.03	.010*	.116	.53±.03	.739	.002	.54±.03	.115	.053	.52±.03	.091	.061	.53±.03	.869	.001	.53±.03	.149	.045
	Low Performers	.52±.03			.54±.04			.53±.03			.53±.03			.54±.04			.55±.03		
20kg CMJ Jump Height (m)	High Performers	.37±.04	.008*	.125	.35±.04	.887	.000	.36±.03	.124	.051	.33±.03	.054	.078	.35±.04	.923	.000	.35±.04	.192	.037
	Low Performers	.34±.04			.35±.04			.34±.04			.35±.04			.35±.05			.37±.04		
Percent Fall Off	High Performers	23.65±3.59	.819	.001	24.44±4.05	.064	.073	23.59±3.77	.539	.008	25.48±4.22	.333	.020	24.44±4.05	.951	.000	24.44±4.05	.021*	.111
	Low Performers	23.92±5.05			22.25±3.96			22.89±4.01			24.38±3.49			24.38±3.11			21.84±3.47		
Waist to Height Ratio	High Performers	.47±.03	.762	.002	.47±.03	.332	.020	.47±.03	.102	.057	.47±.03	.631	.005	.47±.03	.963	.000	.47±.03	.208	.034
	Low Performers	.48±.03			.47±.03			.48±.04			.47±.03			.47±.03			.46±.03		

** Indicates Statistical Significance at p≤0.001, * Indicates Statistical Significance at p≤0.05

Table 4.3 Partial Eta² Analysis

Statistical Significance and Effect Size between High and Low Performing Teams on each Event

	Rifle Marksmanship		Pistol Marksmanship		Land Navigation		Grenade Throw		Obstacle Course		CBRN/WPNS	
	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²
Sandhurst Event	.000**	.924	.000**	.994	.000**	.990	.000**	.914	.000**	.910	.000**	.973
Push-up Score	.057	.077	.391	.016	.010*	.134	.545	.008	.101	.057	.015*	.121
Sit-up Score	0.36*	.092	.028*	.101	.083	.064	.275	.026	.638	.005	.011*	.133
Run Score	.056	.077	.049*	.082	.040*	.089	.405	.015	.755	.002	.042*	.087
Total Score	.001**	.203	.008*	.144	.002*	.188	.580	.007	.356	.019	.000**	.249
Age	.000**	.269	.000**	.286	.891	.000	.032*	.096	.002*	.184	.001**	.216
Height	.188	.037	.701	.003	.909	.000	.389	.016	.395	.016	.592	.006
Mass	.997	.000	.676	.004	.787	.002	.745	.002	.066	.072	.292	.024
Waist Circumference	.914	.000	.086	.063	.617	.005	.288	.025	.070	.070	.093	.060
0kg CMJ Flight Time	.470	.011	.208	.034	.718	.003	.013*	.126	.063	.073	.967	.000
0kg CMJ Jump Height	.383	.017	.188	.037	.608	.006	.015*	.123	.073	.068	.911	.000
20kg CMJ Flight Time	.448	.013	.838	.001	.738	.002	.089	.062	.158	.043	.795	.001
20kg CMJ Jump Height	.450	.012	.806	.001	.702	.003	.066	.072	.145	.046	.744	.002
Percent Fall Off	.969	.000	.035*	.093	.739	.002	.333	.020	.724	.003	.305	.023
Waist to Height Ratio	.489	.010	.185	.038	.673	.004	.635	.005	.384	.017	.258	.028

	One Rope Bridge		Vertical Challenge (12' Wall)		Recon		DMI Challenge		Course Time		Overall Finish	
	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²	Statistical Significance	Partial Eta²
Sandhurst Event	.000**	.970	.000**	.993	.000**	.944	.000**	.966	.000**	.991	.000**	.949
Push-up Score	.713	.003	.184	.038	.004*	.164	.879	.001	.267	.027	.028*	.101
Sit-up Score	.442	.011	.417	.014	.776	.002	.055	.078	.057	.077	.164	.042
Run Score	.451	.011	.899	.000	.590	.006	.614	.006	.029*	.100	.112	.054
Total Score	.732	.002	.270	.026	.131	.049	.513	.009	.017*	.117	.010*	.135
Age	.017*	.100	.003*	.173	.546	.008	.128	.050	.000**	.234	.009*	.139
Height	.428	.012	.352	.019	.398	.016	.160	.042	.158	.043	.580	.007
Mass	.306	.019	.127	.050	.487	.011	.126	.050	.348	.019	.388	.016
Waist Circumference	.644	.004	.004*	.086	.245	.029	.086	.063	.102	.057	.047*	.083
0kg CMJ Flight Time	.005*	.135	.465	.012	.048*	.082	.100	.058	.968	.000	.826	.001
0kg CMJ Jump Height	.007*	.129	.487	.011	.059	.075	.121	.052	.914	.000	.768	.002
20kg CMJ Flight Time	.010*	.116	.739	.002	.115	.053	.091	.061	.869	.001	.149	.045
20kg CMJ Jump Height	.008*	.125	.887	.000	.124	.051	.054	.078	.923	.000	.192	.037
Percent Fall Off	.819	.001	.064	.073	.539	.008	.333	.020	.951	.000	.021*	.111
Waist to Height Ratio	.762	.002	.332	.020	.102	.057	.631	.005	.963	.000	.208	.034

* indicates statistical significance at p≤0.05, ** indicates statistical significance at p≤0.01

DISCUSSION

Comparison of Top Three vs Bottom Three Teams

Rifle and Pistol Marksmanship.

Age was statistically significant between high performing and low performing teams which, may be due to the potential increased time and experience using an M-16. An analysis of Australian rules football players suggest that there is a statistically significant difference in age between starters and non-starters (Young et al., 2005). Young et al., (2005) also suggests that years of playing experience was statistically significantly different between starter and non-starters.

Since experience is considered to be a factor in marksmanship performance (Robazza, Bortoli, & Nougier, 1998), the increase in experience may also effect the cadet's physiological arousal. According to Robazza, Bortoli, and Nougier, (1998) experienced archers are able to modify physiological arousal even under a high arousal condition. During the rifle marksmanship event the cadets were in the prone or kneeling position which allows the rifle to be supported by an object other than cadet's extremities. The physical fitness total score was statistically significant between high and low performing teams which may suggest greater control of physiological arousal (reducing heart rate before taking a shot) or greater control of the weapon because of higher levels of physical fitness. Sit-up score may be statistically significant due to the strong positive relationship between total physical fitness score and sit-up score ($r= 0.54$), not necessarily because abdominal muscular endurance affects marksmanship, especially in the prone and kneeling positions.

Land Navigation.

Run score and total score are statistically significant which, may be due to the distances in which high performing teams were required to cover to attain more check points than low performing teams. Push-up score reached statistical significance which may be a result of strong positive correlations between; run score and push-up score, and total score and push-up score. This suggests that physical fitness may separate high and low performers during land navigation, that is time and number of check points dependent. Land navigation may be considered a highly technical skill because physical fitness would not make a difference if the participants were unable to use a map and compass. Intuitively, technical skills should be influenced by experience and age although, that was not the case in this study. Age was not statistically significant which may be a result of the time that was provided before the event started; for cadets to strategically plan their route to reach as many check points as possible. Providing time for teams to plan their route may limit identification of any differences between more or less skilled teams in land navigation.

Grenade Throw.

The grenade throw may be dependent on strength and power. During the grenade throw event cadets had to throw a grenade from a supine or kneeling position to a target 75 ft away. Most cadets had a hard time just throwing the grenade that distance much less accurately hit their target. In an article looking at collegiate baseball players Lachowetz, Evon, and Pastiglione, (1998) found that an eight week strength training program improve baseball throwing velocity. An evaluation of male USA collegiate, Olympians, and World Leaders in the shot put and discus showed an incremental increase in strength and power with each increase in competitive level

(Stone, Moir, Glaister, & Sanders, 2002). Data from this article and other literature suggest that strength and power may influence the ability to throw a grenade. Age was also statistically different although the high performing teams were actually younger suggesting that the grenade throw is not dependent on age and experience.

Obstacle Course.

Body mass and waist circumference were not statistically significant although, the p values were .066 and .07, respectively. Interestingly, body mass and waist circumference were greater in the high performing teams. Again, not statistically significant (p= 0.073) but the unloaded jump height of the high performing teams were higher than the low performing teams. These results are in agreement with a study evaluating a Canadian indoor obstacle course. Jette, Kimick, and Sidney, (1990) found statistically significant correlations between obstacle course time and strength index (grip strength, shoulder press, and leg press) and muscular endurance. When the top ten and bottom ten performers were separated the aerobic power of the faster performers was 33 % higher than the slow performers (Jette et al., 1990). In the current study, aerobic fitness and muscular endurance were not identified as important indicators of better performance although, differences between high and low performing teams may be limited by the similarities of aerobic fitness and muscular endurance. Also, higher performing teams were statistically older than the lower performing teams suggesting an experience effect. The author was unable to identify specific training facilities that may have impacted the high performing teams' performance.

CBRN/WPNS.

Age and all measures of the PFT were statistically significant between high and low performers. Age suggests experience may have played a large part in assembly of the weapons especially when vision was hindered from the gas mask. The CBRN/WPNS task was not physical in nature as participants were required to stand around a table while assembling the weapons. The significance of PFT measures may have happened by chance.

One Rope Bridge.

Age was identified as statistically significant and may be influential because of the skill that is required to complete this event. Knot tying, ability to set up the Swiss seat, and communication between team members is critical to quickly completing this event. Once on the rope the cadets have to use their upper body strength to pull themselves from one side to the other. Strength and power measures were also statistically significant suggesting a greater ability of the top performing teams to lift their body to the rope and pull themselves across the distance of the one rope bridge.

Vertical Challenge (Wall).

Age was statistically significant which may be an indicator that high performing teams were able to execute their plan more efficiently. The event started by blindfolding the squad leader forcing another team member to execute the plan. An analysis of female rock climbers by Grant et al., (2001) found an age difference of seven years between elite and recreational rock climbers. Teams that performed well seemed to have a plan and were able to traverse the obstacle within a couple of minutes. Some lower performing teams were unable to complete the obstacle in the time allotted. Although not measured in this study, team work and leadership may have played influential roles in team performance.

Waist circumference was also statistically significant although the high performing teams had greater waist circumference. Intuitively, having a larger waist circumference would be detrimental to climbing over a vertical object. This provides more credence that age or experience was the primary factor influencing success on the vertical challenge.

Director of Military Instruction (DMI) Challenge.

The DMI challenge required participants navigate a simulated mine field using strategically placed bricks and boards to walk on. After crossing the mine field team had to carry a Zodiac inflatable raft around a ~800 m course as quickly as possible. This was the last event of the competition before team ran short distance (~300 m) to the finish line. Analysis of this event revealed no statistically significant physical or performance characteristics between top and bottom teams. The performance of successful teams may have been motivated by family and friends that were watching this event. Family and friends were not allowed on the training grounds during the performance of other events.

Course Time.

Run and total score were statistically significantly different between high and low performing teams. The load that cadets were expected carry consisted of a load bearing vest (canteen and ammo pouches), M-16, and two cadets carried a day pack (back pack). The literature suggests that as the load a soldier has to carry gets heavier stronger soldiers are able to move faster (Marriott & Grumstrup-Scott, 1992). This suggests that as the load gets lighter (in the case of the participants of the Sandhurst Competition) there would be a greater emphasis on aerobic fitness. The results from this study coincide with the scientific literature evaluating load carriage over long distances.

Overall Finish Place.

Push-up and total score, age, waist circumference, and fat mass were statistically significantly different between high and low performing teams. The differences seen among the physical fitness test measures suggest that the push-up event and overall physical fitness score may be a good evaluation of potential performance on the Sandhurst competition. This cannot be extrapolated to active duty military due to the drastically lighter load the cadets are carrying in the Sandhurst competition compared to the load carried during overseas military operations (Knapik, Reynolds, & Harman, 2004).

Also, according to Young et al., (2005) age was able to separated starters from non-starters in rugby. This supports the contention that age may be able to separate high performing teams compared to low performing teams.

The physical characteristic of waist circumference also reached statistical significance although, teams with a larger waist circumference performed better.

Comparison of all Effects Sizes (Partial Eta²).

To summarize, the comparison of all Partial Eta² values provides insight into the importance of each variable in relation to the entire event. Partial Eta² was averaged for all events to provide an evaluation of each variables influence on the Sandhurt competition. This evaluation revealed that age had the greatest effect on the entire competition (Avg. Partial Eta² = .146). The second most influential variable was physical fitness total score (Avg. Partial Eta² =

.096). There are numerous physical and performance variables that are of similar importance. See Table 4.3

Summary.

The evaluation of Partial Eta² suggests that teams that are older and therefore, are likely to have more experience executing military tasks perform better than younger teams. The data also suggests that PFT total score was the second best indicator of performance on the Sandhurst Competition. Again, it needs to be mentioned that data and conclusions cannot be extrapolated to active duty soldiers. There are drastic differences in load carried by the participants of the Sandhust Competition and that of soldiers executing combat operations and that will change the importance of physical and performance characteristics.

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CHAPTER 5

DISCUSSION AND CONCLUSIONS

These studies are unique due to the nature of the Sandhurst competition and the analysis of aggregate team characteristics to indicate potential differences between team performances. The correlation analysis resulted in findings that differed from the literature, although they may be a result of the participants' high aerobic and muscular endurance fitness levels.

The strong positive correlations that were found between the measures of the APFT suggest that an individual who performs well on one event has a high probability of scoring well on all events. The inverse may also be the case although participants in this sample did not score poorly, the average points on each event and total score was 95 and 290, respectively. Based on the factor analysis (page 43) the events of the APFT evaluate very similar characteristics. Theoretically, if you score well on one the push-up event you will score well on all events. The inverse may also be true, meaning if you score poorly on the push-up test you will likely score poorly on all tests. What do three PFT events explain that one event doesn't?

There were weak positive correlations between measures of strength and power and running; however, the literature suggests that increased strength and power may improve running economy and, therefore, run time (Anderson, 1996; Paavolainen et al., 1999). The weak positive correlations may be explained by the trained state of the cadets and the physical fitness training program typically performed by Army ROTC cadets. The cadets are moderately trained aerobically based on their respective 2-mile run times (Run time = 755±45 sec). The small standard deviation suggesting a very homogenous population in run time may provide explanation for the weak positive correlations. The training program will also influence the characteristics that cadets can develop. The participants have a similar jump height (.45±.05 m) when compared to female dancers (.46±.18 m) (Marshall & Wyon, 2012) and female college volleyball players (.57±.06 m) (Gentry & Miller, 2014) and lower jump heights than Division I football players (.74±.07 m) (Davis, Barnette, Kiger, Mirasola, & Young, 2004). The poor jump height of the cadets as a group and the narrow range of jump heights between cadets may limit the strong positive correlation between strength and power and 2-mile run time. In the Army physical fitness training program, it is stated that calisthenics are the basis of the Army strength training program (Department of Defense, 2010). From a training perspective, it has been reported that calisthenics may limit strength and power adaptations (Harman et al., 2008), which then limit the strength and power of cadets and soldiers.

The relationships identified in this study suggest that the events of the APFT need to be reconsidered due to their strong positive correlations. The high performances on the events of the APFT and low performance on measures of strength and power suggest that Army physical fitness training does not train all physical characteristics adequately. Although physical characteristics are just one aspect of training, careful consideration needs to be made when designing field training exercises due to the effect age and experience have on military skills performance.

The analysis of each team compared to the winning team did not provide indication of physical characteristics that may lead to successful performance. The analysis did reveal age was statistically different between the winning team and 7 out of the 12 other teams. Three teams with the oldest mean age finished within the top 10 of 55 teams. This adds support that age, and therefore experience, may play a larger role than expected in the successful performance of military tasks. Research evaluating differences between Special Forces units and infantry units has not been done, although analysis of two different articles suggests that Special Forces units (Navy SEALS) (Prusaczyk et al., 1995) may be older and, therefore, more experienced than regular infantry units (Sharp et al., 2008).

In response to the limited information from the team analysis, the top three and bottom three teams were compared in an attempt to identify underling physical and performance characteristics that were not readily identifiable from the initial analysis.

These analyses lead to the conclusion that each event has different and specific physical or performance characteristics that may improve a team's chance of success on the Sandhurst Competition. Overall, the data suggest that age separates high and low performers. The higher performing teams were older than the low performing teams. Most cadets begin their military training on or around the age of 18 when they begin the ROTC program. A team that has an average age of 23 would be considered to have 5 years of experience performing military tasks. This naturally leads to large discrepancies in training age (time spent training for specific tasks or activities). Literature evaluating differences between novice, subelite, and elite athletes suggest that age separates each level of playing ability or competition (Gabbett, 2009; Gabbett et al., 2009).

The second most important variable seems to be total PFT score. The total PFT score provides an overall indication of the team fitness and their ability to perform tasks of muscular endurance and aerobic power. The author believes this result is a consequence of the Sandhurst Competition events and the load each participant was expected to carry. The events that are physically demanding in nature (obstacle course, land navigation, DMI challenge, total course time, etc.) took several minutes or hours to complete. It's commonly understood that as the duration of activity gets longer, there is a greater dependence on aerobic mechanisms for energy production and greater reliance on Type I muscle fibers for force production. The duration of activity of Sandhurst events, to some extent, match the time demands of the PFT events.

Another reason the PFT score was found to be important may be due to the load that participants were expected to carry. The competition load was much less than that of active duty soldiers. The exact weight of the equipment the participants had to carry wasn't directly measured although Goff, Walker, and Gloystein (2011) suggest that average participant load was ~9kg. The combat load of active duty soldiers in hostile countries typically exceeds 45kg (Goff et al., 2011; Knapik et al., 2004). Intuitive, as the load that a soldier has to carry increases, a greater demand would be placed on the soldier's ability to produce force. The literature on combat loads suggests that Sandhurst competitors carried a load atypical for active duty soldiers, meaning the results and conclusions from this study cannot be extrapolated to the active duty population.

The results from this study provide the first information on team characteristics and their influence on military tasks. Future research should attempt to increase the external load soldiers or cadets have to carry during simulated military operations to identify combat specific team characteristics. Research during the Sandhurst Competition could evaluate the perceptions of combat experienced soldiers as a method of determining the applicability of the Sandhurst Competition to combat operations.

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