THE RELATIONSHIP BETWEEN THE ARMY PHYSICAL FITNESS TEST AND A TWELVE-MILE RUCK

A Thesis

by

HARRISON AJ HALL

BS, University of Southern Maine, 2016

Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

in

KINESIOLOGY

Texas A&M University-Corpus Christi
Corpus Christi, Texas

August 2018

THE RELATIONSHIP BETWEEN THE ARMY PHYSICAL FITNESS TEST AND A TWELVE-MILE RUCK

A Thesis

by

HARRISON HALL

This thesis meets the standards for scope and quality of
Texas A&M University-Corpus Christi and is hereby approved.

Randy Bonnette, EdD
Chair

Toyin Ajisafe, PhD
Co-Chair

Mikaela Boham, EdD
Committee Member

August 2018

ABSTRACT

The purpose of this study was to investigate the association between the Army Physical Fitness Test (APFT) and the twelve-mile ruck assessment of Army Reserve Officer Training Corps (ROTC) cadets (CDT's). The APFT is a vital part of every soldiers time in the US Army because it is the only fitness test required to pass twice a year, and also allows soldiers to receive pay and be considered for promotions upon passing the assessment. The twelve-mile ruck is an assessment which CDT's march twelve miles carrying 35 pounds in less than three hours, but is only performed once. Due to the evident importance of training for the APFT, officers in the US Army have been found to overtrain in running, push-ups, and sit-ups, which has caused injuries from repetitive stressors, and has not prepared servicemen for heavy load carriage. Since the APFT is crucial to all soldiers for career advancement, and the twelve-mile ruck relates directly to combat specific tasks (i.e., soldiers carry up to 130 lbs. of equipment during combat), it is important to investigate if the APFT is correlated to the twelve-mile ruck to determine if a more combat specific assessments should be utilized for such important fitness standards in place of the APFT.

A linear multiple regression analysis was performed in a stepwise backward model to interpret the relationship between seventeen Army ROTC Cadets' (Age = 20.5 ± 2.50, weight (kg) = 71.69 ± 11.74, height (m) = 1.67 ± .09, BMI = 25.45 ± 5.11) archived APFT measures, and twelve-mile ruck times. Significant positive relationships between BMI ($r = 0.771$, $p = 0.001$, $n = 17$), and weight (kg) ($r = 0.579$, $p = 0.007$, $n = 17$) when compared to the twelve-mile ruck were found. Also, a significant relationship was observed between the two-mile run score ($r = -0.654$, $p = 0.002$, $n = 17$) and the twelve-mile ruck. These results indicate there were significant relationships between the APFT and a twelve-mile ruck

DEDICATION

This thesis is dedicated to Peter Dawson and Laurie Hall, for without either of you two stepping into my life and challenging me to go to college to attain my bachelor's degree, I would not be achieving my master's degree.

ACKNOWLEDGMENTS

I would like to thank my committee chair, Dr. Randy Bonnette, and my committee members, Dr. Toyin Ajisafe, and Dr. Mikaela Boham, for their guidance and support throughout the course of this research. Their help has been an outstanding contribution in my path to attain a master's of science degree.

Thanks also go to my friends and colleagues and the department faculty and staff for making my time at Texas A&M University-Corpus Christi an enjoyable experience. I also want to extend my gratitude to my parents, who have supported, and trusted me with everything I do, and have helped me get to where I am today.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I: INTRODUCTION

The Army Physical Fitness Test (APFT) consists of a timed two-mile run, two minutes of sit-ups, as well as two minutes of push-ups. It has been utilized by the US Army as a baseline physical readiness exam since 1980 (Harmen, et al., 2008; Knapik, & East, 2010; Shaul, 2017). The scale utilized to score the exam is normalized by age and biological gender (see Appendix B). Each of the three parts of the exam (timed run, push-ups, and sit-ups) are worth 100 points and combine for a 300 point total possible score. If a soldier fails to meet the height and weight ratio requirements (see Appendix C) of the APFT, the soldiers body fat percentage is measured with a tape measuring test (tape) of the neck and hips (Talbot, et al., 2013). If a soldier fails to meet the height and weight requirements, and does not pass the tape measure assessment, the service member would be placed into a remedial training group. Once in remedial Physical Training (PT), the next APFT exam must be improved upon in any measure (i.e., scoring one point higher on the run, push-ups, or sit-ups, is considered improvement) (Harmen, et al., 2008; Talbot, et al., 2013). If the exam is not improved in any way, the soldier will be discharged from the US Army. Over the past 20 years different testing recommendations have been put forth in order to alter the APFT; however, none have been approved due to both the high costs of equipment suggested, and the lack of evidence-based research supporting the assessments (Myers, & Panzino, 2017; Shaul, 2017).

In order to be commissioned into the US Army officers must hold citizenship in the United States, have a high school diploma, fall between the ages of seventeen and 34 years of age, pass both the Armed Services Vocational Aptitude Battery (ASVAB) test and the Military Entrance Processing Station (MEPS) medical exam, and then successfully complete Cadet Summer Training (CST) (MSG C. Pena, US Army, personal communication, March 18, 2018).

Additionally, in order to be commission into the United States Army, each contracted cadet (CDT) must pass the APFT assessment with at least a 60% score at CST, and twice a year after the initial test (PFC J. Del Bosque, US Army, personal communication, March 23, 2018). Further, the APFT is utilized for all enlisted, and officer soldiers of all ranks to determine whether or not a soldier is paid, promoted, or even discharged from the Army (MSG C. Pena, US Army, personal communication, March 18, 2018). More specifically, if a soldier fails an APFT assessment it is legal for the US Army to withhold pay, as well as potential promotional deals, and in extreme cases (i.e., failing multiple APFT assessments consecutively), to discharge the soldier from the US Army (MSG C. Pena, US Army, personal communication, March 18, 2018). Additionally, all soldiers becoming an officer must take part in a twelve-mile ruck assessment during advanced training in Reserve Officers' Training Corps (ROTC), or Officer Candidate School (OCS); if a soldier fails to successfully complete either assessment, the soldier will likely be discharged from the US Army (MSG C. Pena, US Army, personal communication, March 18, 2018). The difference between OCS and ROTC is that ROTC is a program in which students are enrolled in a university where ROTC is available (US Army, Navy, or Air Force ROTC); students will take military science classes, complete summer camps, have field training during the school year, and have access to experienced military leaders year round; whereas the OCS route enables students enrolled in any four-year degree to commission into the military after completing basic training, and CST in only two summers (PFC J. Del Bosque, US Army, personal communication, March 23, 2018). In addition, cadet's (CDT's) are the youngest ranking officers, and are only titled CDT when contracted with an ROTC program, are completing training through OCS, or are enrolled in a military academy (PFC J. Del Bosque, US Army, personal communication, March 23, 2018). More so, because soldiers on the enlisted side of the

Army do not participate in CST, CDT's are the only soldiers specifically tested on the ability to perform a twelve-mile ruck assessment in order to commission.

The twelve-mile ruck performed at CST requires CDT's to complete a load carriage of 35 pounds inside a rucksack for twelve-miles in just three hours, and it has a failure rate of anywhere between fifteen to 50 percent at CST alone (Molinaro, 2018). It is also important to note that the failure rate of basic training camp for the United States Army is fifteen percent for newly enlisted soldiers (McHugh, 2018). This may suggest that the US Army APFT needs more rigor, or implementation of a variety of physical assessments, which may help eliminate soldiers potential of failing the twelve-mile ruck later on, ultimately saving the US Army tens of thousands of dollars per CDT that do not complete CST due to physical inabilities (Talbot, et al., 2013). Further, an estimated $25,500.00 (Talbot, et al., 2013) to $35,000.00 (Lalich, 2001) is spent on every CDT during the recruiting processes, and throughout basic training camp on every CDT. Thus, if the APFT tested physical abilities such as explosive strength or power, it may potentially save the US Army money.

The US Army has recently began to implement the Army Combat Readiness Test (ACRT), which includes a variety of physical assessments such as a deadlift, two-mile run, shuttle runs, loaded carries, and sit-ups. It is only performed at select sites since it is not yet mandated Army wide; however, will be Army wide by 2020 (Lopez, 2018). Until then, the APFT is the only test used by the US Army, for qualifying a prospective soldier as physically fit, and is the only physical assessment possibly prohibiting a soldier from receiving pay, promotions, and remaining in the military. Furthermore, this is a main factor as to why US Army officers will only train units to pass the APFT, and may not train differently to include weight training (Schuh-Renner, 2017). Unfortunately, since the APFT does not include any loaded carriage, or any explosive strength test components, training for the APFT leaders have to set goals of simply passing the 300 point exam at a minimum of 60 percent (Crowder, Ferrara, & Levinbook, 2013; Fawley, 2012; Harman, et al., 2008). Yet, some US Army officers utilize the APFT as a combat readiness screening assessment, and therefore, conduct training specifically towards maxing the APFT with a perfect score of 300 (Crowder, Ferrara, & Levinbook, 2013; Harmen, et al., 2008; Fawley, 2012; Talbot, et al., 2013), which is also commonly referred to as the Physical Training (PT) test. Thus, including some type of loaded carry within the APFT may spark the awareness needed for future leaders of the US Army to include more strengthening type workouts into PT sessions.

However, training programs lead by uneducated officers have the potential to cause more harm from just running due to overuse injuries (Schuh-Renner, 2017). This is important because overuse injury rates have been shown to correlate directly with increased running when officers decide to dramatically intensify endurance mileage each month, instead of balancing between endurance and strength training (Schuh-Renner, 2017). Further, aerobic training in concurrence with resistance training proves to be the most effective training style in enhancing APFT scores, as well as combat specific assessments such as heavy loaded rucking (Kraemer, et al., 2004; Santtila, Häkkinen, Karavirta, & Kyröläinen, 2016; Showman, & Hensen, 2010). This suggests officers within the Army should begin broadening the training regimen for units, especially if a unit has trouble passing the PT test, or experience overuse musculoskeletal injuries as a result of running too often and too much, and completing repetitive forces such as push-ups and sit-ups daily from PT.

Although the APFT is widely utilized as a combat readiness tool by US Army officers, which is something the US Army has made clear should not happen, rucking is often practiced in training in order to prepare for combat (Schuh-Renner, 2017). However, as aforementioned, US Army officers have not included rucking, or a variety of anaerobic and explosive exercises within the PT sessions, leading to overuse injuries (Schuh-Renner, 2017). Nonetheless, the purpose of including long distance rucks in a soldiers training is to allow service members to train gradually for the physical requirements of the armed forces in order to decrease injury, and increase the ability to withstand physical stress during combat (Schuh-Renner, 2017). Resistance training is thus critical as it helps by increasing basic strength; a service member can be more explosive, or move a heavy load such as a rucksack, or full combat gear in a time effective manner. Harman, et al., (2008), also suggested that no APFT component related to explosive strength or power, and recommended a 400m-sprint, or vertical jump, be implemented into the APFT as it would be cost effective, and more combat specific than the current three components of the APFT.

Unfortunately, there are no studies to date examining the specific variables and scaled scores of the APFT compared to those of the twelve-mile ruck results as this study does. Due to the evident necessity of improving the training of soldiers, it is appropriate to question how the APFT correlates to a combat specific task such as the twelve-mile ruck. Therefore, this study investigated the association between the APFT measures and the twelve-mile ruck among ROTC CDT’s to see if correlations exist. If so, this evidence may be used to address the importance about raising fitness standards while training for combat. Understanding the relationship between the two may also aid in a decrease of injury from overuse work, increase tactical athletic performance, decrease the dropout rate of US soldiers, and decrease costs for the United States Army.

The purpose of this study was to investigate if an association exists between the APFT measures and the twelve-mile ruck assessment of Army ROTC CDT's. The APFT results utilized are the CDT's most recent scores leading up to the twelve-mile ruck assessment. The variables included in the APFT are the two-mile run results, two-minute push-up results, two-minute sit-up results; as well as demographic information such as: age, gender, height, weight, and body mass index (BMI). The APFT is scored utilizing an algorithm developed by the US Army which scales the results to a 100 point scale for each event. For example, even though a thirteen minute two-mile run time scores 100 points for an eighteen-year-old male, a female of the same age with a two-mile run time of fourteen minutes will receive 100 points as well. Therefore, results on the individual performance tests within the APFT (i.e. two-mile run, two-minutes of push-ups, and two-minutes of sit-ups) will be observed as scores out of 100, instead of a raw score, so error for gender or age does not impact the overall relationship of the variables. Additionally, the twelve-mile ruck assessment times were compiled directly from the twelve-mile ruck assessment completed in January of 2018 from the CDT's training for the Bataan Memorial Death March. Army CDT's were between eighteen and 23 years of age for each gender and were ROTC students at Texas A&M University-Corpus Christi (TAMU-CC).

It was hypothesized body mass index (BMI), weight, and two-mile run times would significantly correlate to the twelve-mile ruck results.

CHAPTER II: REVIEW OF THE LITERATURE

History of Army Fitness Standards

The US Military Academy at West Point produced the first US Army physical fitness assessment in 1858, which consisted of a wall climb, high horse vault, one-or two-mile run (under eight, or eighteen minutes, respectively), ten foot ditch leap, four-and-a-half mile march within one hour, and a three-mile 20 pound ruck under one hour (Knapik & East, 2010; Shaul, 2017). It was not until 1906 that the US Army established a physical readiness training program that was mandatory for all soldiers, consisting of twelve-mile rucks, and eighteen to 30 mile weekly horseback marches for those in cavalry units (Knapik, & East, 2010; Shaul, 2017). This action warranted physical readiness assessments such as a three-day 90-mile horseback riding test and a 45 mile ruck march assessment (Knapik, & East, 2010; Shaul, 2017). Eventually, in 1942, the United States Army implemented the Physical Efficiency Test Battery (PETB) which tested muscular endurance, agility, cardiorespiratory endurance, strength, and change of direction, by adding a 150-yard shuttle, a 75-yard agility run, a four-mile ruck march, push-ups, 20 seconds of burpees, and a loaded carry (Shaul, 2017). Only four years later burpees and loaded carries were discontinued; however, new tests such as the two-minute sit-ups were established; different age and gender brackets for scaling, and normalization of data to compare scores (Knapik, & East, 2010; Shaul, 2017). By 1950 a secondary physical exam was put in place to test combat units which assessed soldiers in a 75-yard dash, the triple jump, a five-second rope climb, and a one-mile run (Shaul, 2017). Eleven years later, in 1961, the PETB and the Physical Achievement Test (PAT) were removed and replaced with the Physical Combat Proficiency Test (PCPT) demanding soldiers to take part in a 40 yard low crawl, horizontal ladder rungs, an agility test, a grenade target throw, and a one-mile run (Shaul, 2017). Eight years later, three more tests were added for more specific training programs such as the Minimum Fitness Test, Airborne Trainee Physical Fitness Test, and an Inclement Weather Test. By 1973 the Army Physical Fitness Evaluation (APFE) was established by combining seven assessments into one (Knapik, & East, 2010; Shaul, 2017).

The current Army Physical Fitness Test (APFT) was implemented in the US Army as the baseline physical readiness exam in 1980, and consists of a timed two-mile run, two minutes of sit-ups, and two minutes of push-ups (Harmen, et al., 2008; Knapik, & East, 2010; Shaul, 2017). The scale utilized to score the exam is affected by age, gender, height, and weight. The day prior to the APFT each soldier will complete a height and weight ratio assessment. If this assessment is failed, then the soldier is required to complete the body fat assessment described earlier (Talbot, et al., 2013). If a soldier fails any part of these tests (i.e. push-ups, body fat assessment, two-mile, and sit-ups) they are placed into a remedial Physical Training (Harmen, et al., 2008; Talbot, et al., 2013). Remedial Physical Training (PT) is utilized to train soldiers to pass the APFT, and typically will begin earlier, or last longer than the standard PT.

Within the past two decades different testing recommendations have been put forth and suggested to the US Army (Myers, & Panzino, 2017; Talbot, et al., 2013), but none have been accepted. Further, little evidence-based research supporting the assessments is provided (Myers, & Panzino, 2017; Shaul, 2017; Spiering, et al., 2012). As explained earlier, rucking was a part of the Army fitness tests initially (Knapik, & East, 2010; Shaul, 2017), and was stripped from the assessments in lieu of a low budget test full of body weight exercises. Also, there was no equipment needed for these assessments which limited the physiological test that could be conducted, and therefore set the standard of fitness for the US Army.

Costs of Injury Related to Loaded Carriage

Roy, et al., (2016) suggested that due to increased loads being carried by soldiers, commonly referenced as full, “battle-rattle” (full ensemble of equipment worn during military training and combat situations), longer distance marches over rougher terrain, and increased all around physical demands, that musculoskeletal injuries (MSI’s) are on the rise. This is critical as MSI’s have been found to account for double the amount of medical evacuations as compared to combat injuries, and are the main cause for ambulance evacuations in the US Army (Roy, et al., 2016). MSI’s also represent the majority of injuries occurring during PT, and recreational sports within the US Army (Sefton, Lohse, & Mcadam, 2016). Additionally, over $600,000.00 is spent on US Army on MSI’s annually (Sefton, Lohse, & Mcadam, 2016), which has cost the US Army billions of US dollars over time (Myers, & Panzino, 2017). The most commonly related MSI’s associated with heavy load carriage are the low back, knee, and ankle injuries (Roy, et al., 2016; Schuh-Renner, 2017).

Orr, Pope, Johnston, and Coyle, (2015), suggest the military is changing, and is allowing more female soldiers to serve in the US Army. Despite this increase in number of females serving, there are few studies examining risk factors for MSI’s during heavy loads for females (Roy, et al., 2016). However, in one study, Orr, et al., (2015), examined a random population of 401 male and female subjects to determine the difference, or relationships, between genders during load carriage. The study found female soldiers sustained the same injuries as males in the low back, but instead of the ankle as seen in males, females sustained more foot injuries (Orr, et al., 2015). Roy, et al., (2016), also found a correlation between increases in MSI’s in women over men suggesting again that women may be at a predisposed risk for injury during long distance rucks.

Although rucking has been seen to create a number of injuries, poor training programs lead by US Army officers have the potential to cause more harm if training consists of running only (Schuh-Renner, 2017). Injury rates have been shown to directly correlate to increased running when leaders decide to dramatically intensify endurance mileage each month, instead of balancing between spectrums of endurance and strength (Schuh-Renner, 2017). Therefore, Schuh-Renner, (2017) suggested leaders should either discourage running and implement resistance training and long heavy rucks, or, the leader will discourage weight lifting, and rucking, and only make the unit run. Schuh-Renner, (2017), also suggested that training programs need to be balanced to increase performance and decrease injury rates.

Additionally, many studies have indicated that carrying heavy loads over long distances increase risk for injury, and have thus set forth recommendations on how to properly train for long, heavy, loaded military style ruck marches (Roy, et al., 2016). Also, female builds are typically smaller than males, which may predispose them to greater injuries while sustaining heavy loads which should be taken under consideration as well (Orr, et al., 2015). Roy, et al., (2016), suggested rucking with a low percentage of one’s body weight (such as no more than 15% for females, and 26% in males) and building up by 10% increases in intensity or duration. Also, although no study has observed the effects of resistance training on injuries sustained during long distance rucks, Roy, et al., (2016), recommended strength training may decrease injury rates by properly progressing the body for strength and combat readiness. However, although proper resistance training could be an answer to MSI’s, Roy, et al., (2016), also suggested inadequate sleep, increased job stress, and decreased coping ability may be risk factors among civilian occupations for MSI’s, and therefore need to be examined within the military setting in the future.

Although the US Army has not implemented any new physical fitness assessments including equipment to measure strength, agility, and power, due to high costs (Myers, & Panzino, 2017; Talbot, et al., 2013), it may be cheaper to implement these tests to decrease injury rates, increase performance, and decrease premature discharge within its soldiers which ultimately saves costs in the short-and long-term (Talbot, et al., 2013). Talbot, et al., (2013), determined new soldiers cost about $25,500.00 from recruiting processes all the way through basic training, whereas programs which incorporated Master Fitness Trainers (MFT's) aiding Army Reserve National Guard (ARNG) soldiers cost $2,000.00, or for this specific study, about $15.26 to $72.04 per soldier completing the training. A similar study completed in Wisconsin utilizing the Wisconsin Army National Guard found over $35,000.00 is needed to train and recruit a soldier, and only $1,153.00 to pay for the MFT if a soldier was put in remedial physical training programs (Lalich, 2001). This suggested the MFT saved the US Army money through aiding the soldier through proper training regimens, instead of allowing the soldier to continue to suffer from possible overuse injuries or MSI's.

Additionally, screening methods have been developed to decrease the risk of injury, aid in the soldier's physical well-being, and also to decrease the US Army's costs. Such screenings like the 1-1-1 (one-mile run, one-minute sit-ups, one-minute push-ups) (Sefton, Lohse, & Mcadam, 2016), and a screening program similar to the Functional Movement Screen (FMS) (Petersen, & Smith, 2007), have been utilized to determine pre-existing injuries in order to effectively rehabilitate injuries instead of wasting time, money and resources, and further injuring soldiers.

Holliman, and Balyvan, (2000) also suggested that maximal one-repetition strength scores could be predicted through isometric, as well as dynamic strength tests and fat free body mass, which do not include added resistance. Lastly, a similar study conducted found that vertical jump, an explosive power test, could be found by simply using chalk on the subjects fingers (Harman, et al., 2008), to mark the height of the power output. Although this may not be the most accurate way in determining vertical jump, it is an extremely cost effective way of assessing this test (Lee Scott, Head Strength Coach at Texas A&M University-Corpus Christi, personal communication, April 8, 2018).

Training for APFT and Loaded Carriage

The Department of the Army declares cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition to be its five components of fitness (Department of the Army, 1998). The Physical Readiness Training (PRT) ("Army Physical Readiness Training (PRT) Information", 2012) program was put in place for commanders to utilize in order to train their soldiers to achieve combat readiness in the early 1990’s (Department of the Army, 1998; Showman, & Henson, 2010). By 2012 the PRT standards were updated from Field Manual (FM) 7-22, Physical Readiness Training, to Training Circular (TC) 3-22.20, Army Physical Readiness Training (APRT) (“Army Physical Readiness Training (PRT) Information”, 2012; Talbot, et al., 2013). Updates include protocols to decrease injuries caused by excessive running, it implemented phasing and rest periods during training, and it also designed specific combat readiness training (Showman, & Henson, 2010). In addition to these updates, the US Army has begun to implement a MFT program (Showman, & Henson, 2010). The MFT program includes four weeks of training related to the APRT and is geared to educate noncommissioned officers (NCO), and junior officers in implementing the APRT program (“Army Regulation (AR) 350-1”, 2017; Showman, & Henson, 2010). The aim was to enable soldiers who completed the required training and attained the MFT would conduct the unit’s physical training instead of the leader of the unit (“Army Regulation (AR) 350-1”, 2017). Crowder, et al., (2013), suggested an increase in strength and mobility exercises have begun to increase in physical training sessions within recent years. Further, aerobic training in concurrence with resistance training has proven to be the most effective training style in enhancing APFT scores, as well as combat specific assessments such as heavy loaded rucking (Kraemer, et al., 2004; Santtila, Häkkinen, Karavirta, & Kyröläinen, 2016; Showman, & Hensen, 2010).

Although programs are in place, a number of leaders in the US Army focus specifically on training to pass the APFT (Crowder, Ferrara, & Levinbook, 2013; Harmen, et al., 2008; Fawley, 2012; Spiering, et al., 2012; Talbot, et al., 2013), and many do not incorporate resistance training or loaded carries into those training periods (Spiering, et al., 2012). This may be because many of those who lead company or squad PT sessions become confused by the APRT due to the immense amount of material covered in the updated version (Showman, & Hensen, 2010). Due to the influx of information needed in relation to training, the commander leading PT sessions is likely to resort to knowledge from past personal experience (Fawley, 2012). Further, as aforementioned, it can become increasingly more dangerous for soldiers to utilize the APFT as a combat ready exam due to overuse injuries of repetitive training (Showman, & Hensen, 2010), and lacking the strength to accomplish a loaded carry over long distances (Sefton, Lohse, & Mcadam, 2016; Scott, Simon, Van Der Pol, & Docherty, 2015). This is important because infantryman are sent out to seek out the enemy, and will conduct long foot marches combined with explosive bursts of movement regularly to do so (East, 2013; Showman & Hensen, 2010) all while carrying up to 130 pounds of equipment (Schuh-Renner, 2017). Due to such heavy loads, acceleration and velocity will decrease in long distance ruck marches (Koerhuis, Veenstra, Dijk, & Delleman, 2009). This phenomenon points to muscular strength, as well as discomfort within the shoulder and lower back regions as limiting factors towards performance of military style rucks (Koerhuis, et al., 2009). Specifically, Koerhuis, et al., (2009), found 80% VO_2max can be sustained for approximately two-hours, and maximal marching load capacity only reached 66.4% VO_2max over 20 minute periods, limitations during military style rucks may be due to strength, fatigue, and discomfort regions. Chen, & Lee, (1998), discovered the increase in heart rate during heavy loaded road marching replicated the spike in heart rate while performing static, or heavy lifting exercises. Kraemer, et al., (2004), found resistance training combined with endurance training improved two-mile loaded run times, whereas only endurance training had no effect on loaded endurance assessments. Also, resistance training and endurance training increased lower body power over endurance training alone (Kaeamer, et al., 2004). Further, Spiering, et al., (2012), claimed the US Army combat duties include a number of physical lifting, and heavy loading responsibilities, but there does not seem to be a set standard on how to assess these tests. In a study, 35 male soldiers were randomly divided into different training populations consisting of either: 1) full body resistance training concurrent with endurance training, 2) upper body resistance training concurrent with endurance training, 3) only resistance training, or 4) only endurance training (Kraemer, et al., 2004). Although Kraemer, et al., (2004), observed each group (1-4) significantly increased in push-up count; only groups one-and-two did not significantly increase performance in sit-up count, and one-and-two were the only groups which increased in two-mile loaded run times. Additionally, leg power increased significantly for groups one, two and three, as these groups incorporated resistance training, and group four did not (Kraemer, et al., 2004).

Further, Alvar, Sell, and Deuster, (2017), defined power as the product of the force exerted on an object multiplied by the distance the object traveled. Simply put, when a heavy load is placed on a human, it takes strength to be able to move the weight; when the heavy load needs to be moved fast, power is a necessity as distance is a factor of power and the faster the distance is covered, the greater the power (Alvar, Sell, & Deuster, 2017). Therefore, resistance training helps by increasing basic strength so when a service member needs to be explosive, or move a heavy load (such as a ruck, full battle-rattle, etc.) in a time effective manner, the soldier is strong enough to complete the task. Further, Harman, et al., (2008) compared combative assessments such as a casualty rescue, two-mile run, 400m-run, vertical jump, and a horizontal jump, and discovered heavier body mass significantly correlated to fast simulated casualty rescue times as opposed to during a 400m-run, two-mile run, and push-ups. Although the two-mile run correlated most significantly to combat assessments, the vertical jump test correlated highly to peak lower body explosive strength, and is suggested that more than just cardiorespiratory endurance should be examined when determining combat readiness (Harman, et al., 2008). This type of movement correlates to the demands infantryman encounter during combat deployments (Showman and Hensen, 2010). Harman, et al., (2008), also suggested that no APFT component related to explosive strength or power, and recommended a 400m-run, or vertical jump, be implemented into the APFT to fill the gap as it would be cost effective, and more combat specific than other components. Recommendations such as these would force military personnel to learn proper jumping and sprinting mechanics by practicing and installing jumping programs within the physical training programs (Harman, et al., 2008). Thus, it can be suggested that adding strength, or power, assessments to the APFT would force the leaders of the Army to implement greater emphasis in strength training, and invest in soldier’s strength and power capabilities. Since road marching, or rucking, is the most demanding military task (Koerhuis, et al., 2009), Vanderburgh, Mickley, Anloague, and Lucius, (2011) suggested replacing a timed run with a loaded endurance carry because of the positive relationship of loaded endurance training sessions on combat readiness assessments, as well as the APFT.

The MFT program where a soldier is trained for four weeks on all aspects of the APRT (“Army Regulation (AR) 350-1”, 2017) as discussed above, is a step in the right direction. However, four weeks is not enough time to train soldiers to effectively program fitness regimens (Showman, & Hensen, 2010), especially those geared towards combat readiness, injury prevention, and performance enhancement. In one study, MFT’s gave oversight for Army Reserve National Guard (ARNG) soldiers who had failed the APFT (Talbot, et al., 2013). Though supervision of the programming was in place by the MFT, the same study indicates soldiers were not receiving supervised aerobic and/or resistance training sessions (Talbot, et al., 2013), which is most likely due to the fact that ARNG units only meet for one weekend per month, and two-full-weeks out of the year. Showman and Hensen, (2010), suggested the MFT program be extended to a twelve-week long training period where soldiers learn exercise physiology, human anatomy, and sports psychology to enhance knowledge and skills towards coaching specific programs. Additionally, Showman and Hensen, (2010), also suggested four stages, or levels, be created to establish a more in depth training program allowing soldiers to become Certified Strength and Conditioning Specialists (CSCS) by the National Strength and Conditioning Association (NSCA), attain an Olympic Weight Lifting Certification, and also attain a Functional Movement Screening (FMS) certification.

Although body composition is one of the five components of fitness declared by the Army (Department of the Army, 1998), studies have shown training for the APFT has not increased APFT scores in ARNG service members (Talbot, et al., 2013). Steed, et al., (2016), observed the relationship between percent of body fat and the APFT results. Thirteen Army

ROTC CDT's were examined for body fat percentage by utilizing the Army standard method through tape measuring, air displacement plethysmography, and bioelectrical impedance analysis (Steed, et al., 2016). Interestingly, Steed, et al., (2016), found the tape measurement assessment was as an effective way of estimating body fat percentage when compared to the two other technological ways, however, body fat percentages did not associate to the APFT. More specifically, body fat percentage had no impact on the push-up score, but a lower body fat percentage positively affected two-mile run time. These findings might suggest although body fat percentages prove to be a significant factor when training for cardiorespiratory, and muscular endurance, it does not correlate to APFT performance (Steed, et al., 2016). Due to this finding, it can be assumed an overweight individual could still pass the APFT. Although there is a strong relationship between body fat percentage and sports performance, there is a lack of evidence showing the relationship between body fat percentage and military fitness, or combative tasks (Steed, et al., 2016).

Overall, some of the five components of fitness declared by the Army, muscular strength and body composition, are not emphasized enough for leaders of the Army to understand the importance of each. Although responsibility falls on the soldier to enhance performance within the units, service members will often resort to what is known prior to taking on a leadership position (Fawley, 2012), which does not advance the training within the US Army. Research has conclusively proven that aerobic training in concurrence with resistance training proves to be the most effective training style in enhancing APFT scores, as well as combat specific assessments such as heavy loaded rucking (Kraemer, et al., 2004; Santtila, Häkkinen, Karavirta, & Kyröläinen, 2016; Showman, & Hensen, 2010). Whereas simple aerobic and body weight training may only improve APFT results (Kraemer, et al., 2004; Santtila, Häkkinen, Karavirta, &

Kyröläinen, 2016; Showman, & Hensen, 2010), and may lead to a higher increase in injuries (Orr, et al., 2015)

Variables Predicting Military Tasks

The APFT does not correlate significantly to most military specific tasks or assessments, and has not been found to be an adequate test for combat readiness (“Army Physical Readiness Training (PRT) Information”, 2012; Department of the Army, 1998; Crowder, Ferrara, & Levinbook, 2013; East, 2013; Fawley, 2012; Knapik, & East, 2010; Myers, & Panzino, 2017; Showman, & Henson, 2010; Talbot, et al., 2013).

Williams, and Rayson, (2006), studied 177 British soldiers carrying about 30 and 55 pounds for two-miles before and after a ten-week training program. This study also looked at strength, endurance, and anthropometric measurements before and after the program to determine which variables increased and may predict a greater (or worse) two-mile loaded carry time. The study concluded that Fat-Free-Mass (FFM), percent body fat, and a shuttle-run time correlated significantly ($p \leq 0.05$) to the two-mile loaded carry assessment (Williams, & Rayson’s, 2006). Another study found a 34 kilogram loaded two-mile ruck could predict a two-mile unloaded time, a 45 kilogram barbell squat test (Kraemer, Nindl, & Gotshalk, 1998). Additionally, Williams, and Rayson, (2006) observed significant correlations between a maximal box-lift with strength and body composition assessments.

Furthermore, Rayson, Holliman, and Belyavin, (2000), examined 415 British Army soldiers completing 10 to 25 kilogram loaded carries and compared results to $V0_2max$, isometric pull force, static arm flexion endurance, body fat, body weight, and gender. Unfortunately the study reported too much error in methodology to conclude significant results. However, a secondary study by Rayson, Holliman, and Belyavin, (1996), concluded VO_2max, body fat, and body weight all correlated significantly to the loaded carries. Similarly, another investigation determined that two-mile run times, VO_2max scores, and FFM could predict two-mile 30 pound, and 60 pound loaded carries (Pandorf, et al., 2002).

Additionally, Bishop, et al., (1999), found subjects who weighed less (body mass and percent body fat) were able to complete a military style obstacle course containing mostly upper body obstacles faster than those who were not as lean. Separately, different studies found that VO_2max and strength scores proved to be significant predictors of long endurance assessments such as running (Harman, et al., 2008; Jette, Kimick, & Sidney, 1989). Further, the US Navy examined anthropometric values and physical fitness assessments such as the long-jump, three-mile run, 500-yard swim, push-ups, pull-ups, sit-and-reach, 1,000 yard open water swim, and curl-ups on occupational performance (Harman, et al., 2008; Hodgdon, et al., 1998). Occupational performance was assessed through an equipment carry, double scuba tank lift, and a 100-yard rescue swim (Harman, et al., 2008; Hodgdon, et al., 1998). Although all general physical fitness assessments were not shown to have a significant correlation, body mass did significantly predict the outcomes of all three US Navy assessments (Harman, et al., 2008; Hodgdon, et al., 1998).

Lastly, Teplitzky, (1991) observed 4,000 Special Forces Assessment and Selection candidates, and the success rates throughout the program by a regression analysis utilizing APFT scores, and a loaded carry back-pack assessment. The scores from the APFT examination ($r = 0.25$) did not significantly correlate to the pass rate; however, the loaded carry assessment ($r = 0.49$) did significantly correlate, and therefore was a key predictor of success rate within the Special Forces Assessment and Selection program (Harman, et al., 2008; Teplitzky, 1991). These findings suggest a loaded carry may correlate to combat training when compared to an APFT, and should be observed in cadets.

CHAPTER III: METHODOLOGY

Subjects

The subjects for this study were seventeen students from TAMU-CC serving in the Army ROTC Battalion. Each subject was cleared through a Pre-Participation Exam by the Army ROTC Athletic Trainer and Team Physician on campus at TAMU-CC. The age range of the CDT's was between eighteen and 23 years of age and consisted of twelve-males and five-females. All data was recorded by the US Army ROTC student platoon leaders and cadre members which consists of the Lieutenant-Colonel (LTC), Major (MAJ), Master Sergeant (MSG), and Captain (CPT). All data was accessed via archived records via cadre members. Further, the US Army planned, promoted, and executed both assessments. Therefore, no recruiting methods were utilized for this study.

During both examinations a Certified Athletic Trainer (ATC) was on scene, along with three Athletic Training Students, and cadre members. The study was approved by the Texas A&M University-Corpus Christi Office of Research Compliance. No injuries occurred during either assessment.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS version 22.0, IBM Corporation). Data consisted of results from seventeen Army ROTC CDT's on the APFT and twelve-mile ruck assessments. The analysis was performed as a stepwise backward process for scores of the APFT scaled to interpret the relationship between the independent APFT variables, and the dependent twelve-mile ruck times. Data expressed as greater than 95% confidence intervals ($p \leq 0.05$) were considered statistically significant. Additionally, an autocorrelation through the use of the Durbin Watson Test was utilized once a significant correlation was found, and resulted in a normal measurement (1.855). Thus, no first order linear APFT correlation within the multiple linear regression data exists, and the correlation is considered accurate.

CHAPTER IV: RESULTS

A total of seventeen participants, twelve male and five female ROTC CDT's (n= 17) [Age = 20.5 ± 2.50, weight (kg) = 71.69 ± 11.74, height (m) = 1.67 ± .09, BMI = 25.45 ± 5.11] participated in the APFT and a twelve-mile ruck. All subjects took part in height and weight measurements completed within the recorded APFT (collected by cadre members). The APFT and twelve-mile ruck results along with height, weight, and BMI measurements are shown in *Table 1.*

Table 1 - Complete data set of all seventeen CDT's (M#=male, F#=female, P = Pass, F = Fail).

CDT	12 Mile Ruck (Sec)	2 Mile Run (Sec - Score)	2 Min Push Ups (Score)	2 Min Sit Ups (Score)	TOTAL APFT Score	Age (yr)	Wgt (lbs)	Hgt (in)	BMI	P/F
M1	9773	747 - 100	100	84	289	18	146	67	23.6	P
M2	10121	886 - 75	75	70	220	18	139	66	23.1	P
M3	10503	906 - 71	100	95	266	19	170	67	27.4	P
M4	11194	781 - 99	83	58	212	19	152	70	22.5	F
M5	11333	960 - 67	76	61	204	23	190	71	27.3	P
M6	11472	929 - 66	99	70	235	21	142	69	21.6	P
M7	12265	837 - 86	71	65	222	20	168	68	26.3	P
M8	13329	1031 - 53	68	69	190	23	167	68	26.2	F
M9	15069	980 - 53	97	78	228	20	162	61	31.5	F
M10	15880	961 - 57	94	87	238	18	232	71	33.4	F
M11	9866	752 - 100	100	100	300	20	139	65	23.8	P
M12	10925	859 - 81	99	100	280	19	185	75	23.8	P
F1	10695	964 - 94	100	100	294	21	134	63	24.5	P
F2	11731	977 - 92	90	98	280	19	145	66	24.1	P
F3	12270	925 - 100	98	100	298	19	130	63	23.7	P
F4	12266	1059 - 75	76	60	211	20	147	67	23.7	P
F5	10893	888 - 100	100	87	287	20	139	63	25.4	P

Table 1 shows the results of all 17 CDT's for each event and measurement observed within the data set. P = Passed APFT, F = Failed APFT. The score which is lower than 60 (60%) indicates the event which was failed during the APFT.

Collinearity was found within the total APFT score (VIF = 26633.414) and therefore was not utilized in the final data set. A statistically significant relationship between BMI (r = 0.771, p = 0.001, n = 17), and weight (kg) (r = 0.579, p = 0.007, n = 17) *(see Table 2*) was identified when compared to the twelve-mile ruck. Further, a statistically significant relationship was observed between the two-mile run score (r = -0.654, p = 0.002, n = 17) (*see Table 2*) along with the twelve-mile ruck results. Additionally, weight (kg) (r = -0.595, p = 0.006, n = 17) and BMI (r = -0.605, p = 0.005, n = 17) shared a significant negative relationship to the two-mile run score. For more correlations, see Appendix D.

Table 2 - Significant correlations within the data set

	Variables	12MileRuck	2Mile Run	Wgt	Gender	BMI
Correlation	12MileRuck	1.000	-0.654	0.579	-0.066	0.771
	BMI	0.771	-0.605	0.737	-0.241	1.000
Sig.(*p*< 0.05)	12MileRuck	NA	0.002	0.007	0.400	0.001
	BMI	0.001	0.005	0.001	0.175	NA

Although gender did not appear to have a significant role in the outcomes of this study when compared to the twelve-mile ruck (r = -.0661, p = 0.400, n = 17) (*see Table 2),* the model summary showed an R Square value of 0.705 (70.5%) with an adjusted R square of 0.637 (63.7%) when gender, BMI, and two-mile run score were grouped together, as opposed to R square values of 0.65 (65%) and 0.595 (59.5%) for BMI paired with the two-mile run, and BMI results respectively (*see Table 3*).

There were no other significant (p ≤ 0.05) correlations among the data set. BMI showed no significant relationship to push-ups (r = 0.012, p = 0.482, n = 17), or sit-ups (r =

0.024, p = 0.464, n = 17). Additionally, the Collinearity Statistics Tolerance of total APFT score (0.038) will be discussed in terms of significance in the discussion section. (see Appendix D-F for more data sets)

Table 3 - Model Summary. Model 5 (Sex, BMI, 2-Minute Sit Ups, 2-Mile Run), Model 6 (Sex, BMI, 2-Mile Run), Model 7 (BMI, 2-Mile Run), and Model 8 (BMI) are shown below.

Model Summary	R Value	R Square Value	Adjusted R Square
Model 5	0.852	0.725	0.633
Model 6	0.840	0.705	0.637
Model 7	0.806	0.650	0.600
Model 8	0.771	0.595	0.568

CHAPTER V: DISCUSSION

This study investigated the correlation of the APFT and the twelve-mile ruck assessment of Army ROTC CDT's to determine whether the measures which make up the APFT can predict a twelve-mile ruck assessment time. It was hypothesized that: (1) BMI would share a positive relationship with the twelve-mile ruck results, (2) weight of the cadet would share a positive relationship with the twelve-mile ruck results, and the (3) two-mile run outcome would share significant a negative relationship with the twelve-mile ruck results.

Although recent studies have observed the relationship between APFT results and anthropometric measurements with timed loaded carries, no study has investigated specifically whether or not any APFT measurement shares a relationship with the outcomes of a twelve-mile ruck assessment. Harman, et al., (2008) found Fat Free Mass (FFM), body fat percentage, and a shuttle-run time correlated significantly ($p \leq 0.05$) to a two-mile loaded carry assessment. Also, Kraemer, Nindl, and Gotshalk, (1998) found a 34 kilogram loaded two-mile ruck could be predicted by a two-mile unloaded assessment, a 45 kilogram barbell squat test, and body mass. These discoveries relate to this study's findings as BMI, weight, and two-mile run all proved to positively correlate with the twelve-mile ruck. Further, because the APFT does not include any explosive strength or power tests, this study did not investigate the relationship of outside tests with the twelve-mile ruck such as a barbell squat test. It was therefore hypothesized through findings such as these that the two-mile run time, BMI, and weight would be the greatest predictors of the APFT measurements compared to the twelve-mile ruck.

Additionally, this study revealed that two of the three measurements of the APFT (push-ups and sit-ups) did not correlate to the twelve mile ruck results and therefore suggests that the total score of the APFT could not accurately predict how well a CDT will do during a long distance ruck. This finding was also found in Teplitzky's, (1991) study where total APFT scores did not correlate to success rate in Special Forces school, but loaded carries did.

Further, BMI measurements showed no significant relationship to push-ups and sit-ups which replicates what another study found concerning BMI, body fat percentage, and FFM (Steed, et al., 2016). This suggests an overweight soldier has a better chance in passing the APFT than being able to ruck long distances. Further, this provides reason to believe strengthening the basic assessment would aid in eliminating those soldiers which may not be physically fit for the military to begin with, and in the long term, help save the military costs on soldiers which cannot continually pass the PT test.

Limitations

Factors such as precisely weighing each rucksack were not up to the investigators of the study; rather the weight of each ruck is determined by either the leaders of the platoon or the cadre members overseeing the assessment due to US Army protocol. Thus, although this process provides more lifelike situations with how twelve-mile ruck assessments are typically addressed, it is still realized CDT's may carry more or less weight than the stated amount of 35 pounds, and therefore could potentially effect the results.

The US Army is currently in the process of creating two tests assessing physiological systems other than muscular and cardiorespiratory endurance, titled the Occupational Physical Assessment Test (OPAT) and the Army Combat Readiness Test (ACRT) (Myers, & Panzino, 2017). Neither test is required for all US Army soldiers. The OPAT exam is taken just once a year for those units who are currently taking part in the assessment. More so, the ACRT is still being assessed through top US Army leaders for approval (Myers, & Panzino, 2017). Thus, the APFT is the only test currently used to qualify a prospective soldier as physically fit for the US

Army. Since the OPAT and ACRT are neither mandatory nor implemented US Army-wide, neither assessment was observed in this study; however, future research may look at both of these assessments results compared to a twelve-mile ruck.

Also, the number of CDT's that took part in the study was another limitation. Although there was seventeen total participants, there were only twelve male and five female subjects which leaves room for error, and also eliminates the ability to generalize to a larger population, especially as it relates to female soldiers. Therefore, having more subjects of each gender could have provided more accurate data as more subjects allows for a greater amount of statistics.

This study assumed that participants were healthy at the time of physical assessments due to all Army ROTC CDT's at TAMU-CC are put through Pre-Participation Exams and proper physical examinations before taking part in physical training. Also, it was assumed CDT's were taking care of personal nutrition within the time frame of these assessments to the subjects own best ability. Further, when taking part in the physical assessments, it was assumed that participants gave their best effort during the recorded APFT, and timed rucking examinations. Lastly, it was assumed that all data was correct and accurately recorded during both assessments.

Practical Applications

Due to the findings this study suggests that the US Army utilize a complex strength test such as a barbell squat, loaded carry, or deadlift, in place of push-ups and/or sit-ups. By implementing such a strength test, it may aid US Army Officers to utilize the weight room and rucking within training programs. This may aid in decreasing injuries, increasing performance, and decreasing costs for the US Army.

Further, the APFT does not include any strength tests which involve mobilizing heavy weights such as a squat, deadlift, or Olympic lifts. But, Kraemer, Nindl, and Gotshalk, (1998) found that a loaded two-mile ruck could be predicted by a barbell squat test. Thus, this study suggests that a lower body explosive strength or complex lift (barbell squat, deadlift, etc.) should be utilized as an assessment because of its correlation to a loaded carry, and also suggests that future research observe the relationship between such tests and a twelve-mile ruck.

In terms of maintaining a low cost to assess an explosive strength test, a vertical jump test would be of little cost to the US Army to implement in lieu of barbell assessments. Implementing this explosive test would give soldiers a power facet of fitness to develop, as it is clear the research supports the need for power in combat readiness. Although a weighted barbell squat test relates directly to weight training, it would be a step in the right direction for the US Army to implement a vertical jump test.

Overall, increases in equipment and weight being carried by service members in combat scenarios, longer distance marches covered in rough terrain, and increased all around physical demands of being combat ready (Roy, 2016), the results of this study indicate the need to include a strength test such as a barbell squat, deadlift, or olympic lift in the APFT. Lastly, the impacts of such an assessment may force leaders of the US Army to train in other ways (i.e. resistance training, hiking, jumping) which, in turn, may cut down injury costs, increase tactical performance, and even increase fitness level standards throughout the US Army.

REFERENCES

Alvar, B. A., Sell, K., & Deuster, P. A. (2017). *NSCAs essentials of tactical strength and conditioning*. Champaign, IL: Human Kinetics.

Army Physical Readiness Training (PRT) *Information*. (n.d.). Retrieved April 19, 2018, from http://www.armyprt.com/.

Bishop, P.A., Fielitz, L.R., Crowder, T.A., Anderson, C.L., Smith, J.H., and Derrick, K.R., (1999): Physiological Determinants Of Performance On An Indoor Military Obstacle Course Test. *Military Med*. 1999; 164: 891-6.

Chen, Y., & Lee, Y. (1998). Effect of combined dynamic and static workload on heart rate recovery cost. *Ergonomics, 41*(1), 29-38. doi:10.1080/001401398187305.

Clear, J. (2016, February 17). *The Science of Developing Mental Toughness in Your Health, Work, and Life*. Retrieved from https://www.lifehack.org/363967/the-science-developing-mental-toughness-your-health-work-and-life.

Crowder, T. A., Beekley, M. D., Sturdivant, R. X., Johnson, C. A., & Lumpkin, A. (2007). Metabolic Effects of Soldier Performance on a Simulated Graded Road March while Wearing Two Functionally Equivalent Military Ensembles. *Military Medicine, 172*(6), 596-602. doi:10.7205/milmed.172.6.596.

Crowder, T. A., Ferrara, A. L., & Levinbook, M. D. (2013). Creation of a Criterion-Referenced Military Optimal Performance Challenge. *Military Medicine, 178*(10), 1085-1101. doi:10.7205/milmed-d-13-00081.

East, W. B. (2013). A Historical Review and Analysis of Army Physical Readiness Training and Assessment. *CSI Press*, Iii-267. doi:10.21236/ada622014.

Fawley, D. E. (2012). PT And The 8-Step Training Model: Implementing Training Management Every Day. *Infantry; Fort Benning, 101*(3), 37-40.

Harman, E. A., Gutekunst, D. J., Frykman, P. N., Sharp, M. A., Nindl, B. C., Alemany, J. A., & Mello, R. P. (2008). Prediction of Simulated Battlefield Physical Performance from Field-Expedient Tests. *Military Medicine, 173*(1), 36-41. doi:10.7205/milmed.173.1.36.

Harman, E. A., & Frykman, P. N. (1992). The Relationship Of Body Size And Composition To The Performance Of Physical Demanding Military Tasks. *Washington, DC, National Press, 105*(18).

Headquarters, Department of the Army. FM 21-20 Physical Fitness Training. Washington, DC, 1998, http://www.apft-standards.com/files/fm21_20.pdf.

Hodgdon, J.A., Beckett, M.B., Sopchick, T., Prusaczyk, W.K., Goforth, H.W., (1998): *Physical Fitness Requirements For Explosive Ordnance Disposal Divers.* Technical Report, DTIC Accession No. ADA370096. San Diego, CA, Naval Health Research Center, 1998.

Jette, M., Kimick, A., and Sidney, K., (1989): Evaluating The Occupational Physical Fitness of Canadian Forces Infantry Personnel. *Military Med*. 1989; 154: 318-22.

Knapik, J. J., & East, W. B. (2010). Army Physical Readiness Training. *US Army Medical Depot*. doi:10.21236/ada531081.

Koerhuis, C. L., Veenstra, B. J., Dijk, J. J., & Delleman, P. N. (2009). Predicting Marching Capacity While Carrying Extremely Heavy Loads. *Military Medicine*, *174*(12), 1300-1307. doi:10.7205/milmed-d-00-7508.

Kraemer, W.J., Nindl, B.C., and Gotshalk, L.A., (1998): *Prediction of Military Relevant Occupational Tasks In Women From Physical Performance Components.* In: Advances in Occupational Ergonomics and Safety; 719-22.

Kraemer, W. J., Vescovi, J. D., Volek, J. S., Nindl, B. C., Newton, R. U., Patton, J. F., . . . Häkkinen, K. (2004). Effects of Concurrent Resistance and Aerobic Training on Load-Bearing Performance and the Army Physical Fitness Test. *Military Medicine, 169*(12), 994-999. doi:10.7205/milmed.169.12.994.

Lalich, R. A. (2001). An Initiative to Retain Reserve Soldiers Failing to Meet Weight and Physical Fitness Standards: The Wisconsin Army National Guard Experience. *Military Medicine, 166*(3), 204-207. doi:10.1093/milmed/166.3.204.

Scott, Lee, Head Strength Coach at Texas A&M University-Corpus Christi, personal communication, April 8, 2018.

Lopez, T. C. (n.d.). *Army To Administer Four-Part OPAT To Recruits*. Retrieved April 07, 2018, from https://www.army.mil/article/168882.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). *Exercise physiology: Nutrition, energy, and human performance*. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.

McHugh, M. (n.d.). The Top 3 Reasons You Could Fail Basic Training. Retrieved April 07, 2018, from https://www.military.com/join-armed-forces/the-top-3-reasons-you-could-fail-basic-training.html.

Molinaro, K. (n.d.). Hit the right marks in Air Assault School. Retrieved April 07, 2018, from https://www.army.mil/article/51585/hit_the_right_marks_in_air_assault_school.

Pena, C, MSG, US Army, personal communication, March 18, 2018.

Myers, M., & Panzino, C. (2017, August 5). The Army is testing a new combat fitness test. *Armytimes.com*. Retrieved April 19, 2018, from https://www.armytimes.com/news/your-army/2017/08/15/the-army-is-testing-a-new-combat-fitness-test/.

Orr, R., Pope, R., Johnston, V., & Coyle, J. (2015). Gender differences in load carriage injuries of Australian army soldiers. *Physiotherapy, 101*. doi:10.1016/j.physio.2015.03.2066.

Pandorf, C.E., Harman, E.A., Frykman, P.N., Patton, J.F., Mello, R.P., and Bradley, B.C. (2002): *Correlates of Load Carriage and Obstacle Course Performance Among Women*, 2002; 18: 179-89.

Petersen, E. J., & Smith, K. C. (2007). Benefits of a Musculoskeletal Screening Examination for Initial Entry Training Soldiers. *Military Medicine*, *172*(1), 92-97. doi:10.7205/milmed.172.1.92.

Poel, D. (2016). The effects of military style ruck marching on lower extremity loading. *The University of Wisconsin ProQuest Publishing, 10192375*, 1-109.

Powell, G. D., Dumitru, D., & Kennedy, J. J. (1993). The Effect of Command Emphasis and Monthly Physical Training on Army Physical Fitness Scores in a National Guard Unit. *Military Medicine, 158*(5), 294-297. doi:10.1093/milmed/158.5.294

Del Bosque, J, PFC, US Army, personal communication, March 23, 2018.

Rayson, M.P., Holliman D.E., and Belyavin, A. (1996): Development of Physical Selection Procedures For The Brittish Army: Phase 5. Validation. Technical report No. PLSD/CHS5/CR96/021. Farnborough, Hampshire, England. Center for Human Sciences, 1996.

Rayson, M.P., Holliman D.E., and Belyavin, A. (2000): Development of Physical Selection Procedures For The Brittish Army: Phase 2. Relationship Between Physical Performance Tests and Criterion Tasks. Ergonomics 2000; 43: 73-105.

Roger, T. A. (n.d.). A Modest Proposal For Reform In Army Fitness Programs. *Army, 52 (6), 71-73*. Retrieved from https://manowar.tamucc.edu/login?url=https://search.prquest.com/docview/237078616?accountid=7084.

Roy, T. C., Piva, S. R., Christiansen, B. C., Lesher, J. D., Doyle, P. M., Waring, R. M., Sharp, M. A. (2016). Heavy Loads and Lifting are Risk Factors for Musculoskeletal Injuries in Deployed Female Soldiers. *Military Medicine, 181*(11). doi:10.7205/milmed-d-15-00435.

Santtila, M., Häkkinen, K., Karavirta, L., & Kyröläinen, H. (2016). Changes in Cardiovascular Performance During an 8-Week Military Basic Training Period Combined with Added Endurance or Strength Training. *Military Medicine, 181*(9), 1165-1165. doi:10.7205/milmed-d-16-00266.

Schuh-Renner, A., Grier, T. L., Canham-Chervak, M., Hauschild, V. D., Roy, T. C., Fletcher, J., & Jones, B. H. (2017). Risk factors for injury associated with low, moderate, and high mileage road marching in a U.S. Army infantry brigade. *Journal of Science and Medicine in Sport, 20*. doi:10.1016/j.jsams.2017.07.027.

Scott, S. A., Simon, J. E., Van Der Pol, B., & Docherty, C. (2015). Risk Factors For Sustaining A Lower Extremity Injury In An Army Reserve Officer Training Corps Cadet Population. *Military Medicine; Bethesda, 180*(8), 910-916.

Sefton, J. M., Lohse, K. R., & Mcadam, J. S. (2016). Prediction of Injuries and Injury Types in Army Basic Training, Infantry, Armor, and Cavalry Trainees Using a Common Fitness Screen. *Journal of Athletic Training, 51*(11), 849-857. doi:10.4085/1062-6050-51.9.09.

Shaul, R. (2017, November 03). History of the APFT. Retrieved April 07, 2018, from http://mtntactical.com/knowledge/history-of-the-apft/.

Showman, N., & Henson, P. (2010). Army Physical Readiness Training. *Military Review, Fort Leavenworth*. doi:10.21236/ada531081.

Spiering, B. A., Walker, L. A., Hendrickson, N. R., Simpson, K., Harman, E. A., Allison, S. C., & Sharp, M. A. (2012). Reliability of Military-Relevant Tests Designed to Assess Soldier Readiness for Occupational and Combat-Related Duties. *Military Medicine, 177*(6), 663-668. doi:10.7205/milmed-d-12-00039.

Steed, C. L., Krull, B. R., Morgan, A. L., Tucker, R. M., & Ludy, M. (2016). Relationship Between Body Fat and Physical Fitness in Army ROTC Cadets. *Military Medicine, 181*(9), 1007-1012. doi:10.7205/milmed-d-15-00425.

Talbot, L. A., Metter, E. J., Fleg, J. L., Weinstein, A. A., & Frick, K. D. (2013). Cost Effectiveness of Two Army Physical Fitness Programs. *Military Medicine, 178*(12), 1353-1357. doi:10.7205/milmed-d-13-00118.

Talbot, L. A., Metter, E. J., Morrell, C. H., Frick, K. D., Weinstein, A. A., & Fleg, J. L. (2011). A Pedometer-Based Intervention to Improve Physical Activity, Fitness, and Coronary Heart Disease Risk in National Guard Personnel. *Military Medicine, 176*(5), 592-600. doi:10.7205/milmed-d-10-00256.

Teplitzky, M. L. (1991). Physical Performance Predictors of Success in Special Forces Assessment and Selection. *Technical Report, DTIC* Accession No. ADA245729. Alexandria, VA, Army Research Institute for the Behavioral and Social Sciences. doi:10.21236/ada245729.

Thelen, M., & Koppenhaver, S. (2011). Injury Prevention and Performance Optimization in Soldiers of the Army 101st Airborne/Air Assault Division. *U.S. Army-Baylor University Doctoral Program in Physical Therapy,* San Antonio, TX, USA., PMC4458927. doi:10.21236/ada618622.

Vanderburgh, P. M., Mickley, N. S., Anloague, P. A., & Lucius, K. (2011). Load-Carriage Distance Run and Push-Ups Tests: No Body Mass Bias and Occupationally Relevant. *Military Medicine*, *176*(9), 1032-1036. doi:10.7205/milmed-d-11-00069.

Williams, A.G., and Rayson, M.P. (2006): Can Simple Anthropometric and Physical Performance Tests Track Training-Induced Changes in Load-Carriage Ability*? Military Med*. 2006; 171:742-8.

LIST OF APPENDICES

APPENDIX A

Office of Research Compliance Approval

TEXAS A&M UNIVERSITY CORPUS CHRISTI

OFFICE OF RESEARCH COMPLIANCE
Division of Research, Commercialization and Outreach
6300 Ocean Drive, Unit 5844
Corpus Christi, Texas 78412
O 361.825.2497 • F 361.825.2

Human Subjects Protection Program | Institutional Review Board

Date:	February 24, 2018
TO:	Harrison Hall, Graduate Student
CC:	Dr. Randy Bonnette, Faculty Advisor College of Education and Human Development - Kinesiology
FROM:	Office of Research Compliance Institutional Review Board
SUBJECT:	Not Human Subjects Determination

Activities meeting the DHHS definition of research or the FDA definition of clinical investigation and involves one or more human subjects are subject to IRB review and approval.

On February 23, 2018, the Texas A&M University-Corpus Christi Institutional Review Board reviewed the following submission:

Type of Review:	Not Human Subjects Determination
Title:	The Relationship Between The Army Physical Fitness Test and a Twelve-Mile Ruck
Project Lead:	Harrison Hall
IRB ID:	39-18
Funding Source:	None
Documents Reviewed:	Hall.39-18.ORC Confirmation phone call on 2/23/2018 with PI regarding no identifiers.

Texas A&M University-Corpus Christi Office of Research Compliance reviewed the project submitted and determined that the proposed activity **does not meet the DHHS definition for involving human subjects** (45 CFR 46.102(f)/45 CFR 46.102(e)(1/19/2017).

Therefore, **this project does not require IRB approval**. You may proceed with this project.

Please do not hesitate to contact me with any questions at Rebecca.Ballard@tamucc.edu or 361-825-2497.

Rebecca Ballard, JD, MA, CIP — Digitally signed by Rebecca Ballard, JD, MA, CIP Date: 2018.02.24 08:46:52 -06'00'

Respectfully,
Rebecca Ballard, JD, MA, CIP
Director, Research Compliance
Division of Research, Commercialization and Outreach

Page **1** of **1**

APPENDIX B

	Max Weight, by age (Male)				
Height	Min Weight	17-20	21-27	28-39	40+
58	91	—	—	—	—
59	94	—	—	—	—
60	97	132	136	139	141
61	100	136	140	144	146
62	104	141	144	148	150
63	107	145	149	153	155
64	110	150	154	158	160
65	114	155	159	163	165
66	117	160	163	168	170
67	121	165	169	174	176
68	125	170	174	179	181
69	128	175	179	184	186
70	132	180	185	189	192
71	136	185	189	194	197
72	140	190	195	200	203
73	144	195	200	205	208
74	148	201	206	211	214
75	152	206	212	217	220
76	156	212	217	223	226
77	160	218	223	229	232
78	164	223	229	235	238
79	168	229	235	241	244
80	173	234	240	247	250

Appendix B shows the scale utilized for height and weight standards. If a soldier fails this (i.e. is above or below the set standard) the soldier will be tested by a tape measuring assessment to determine body fat percentage. This information can be found in the US Army Field Manual 21-20 (FM 21-20), Headquarters, Department of the Army. FM 21-20 Physical Fitness Training.

APPENDIX C

APFT Maximum/Minimum Score Ranges

Age		Male			Female		
		2-Mile (min:sec)	Push-Up	Sit-Up	2-Mile (min:sec)	Push-Up	Sit-Up
17-21	MAX	13:00	71	78	15:38	42	78
	MIN	15:54	42	53	18:54	19	53
22-26	MAX	13:00	75	80	15:38	46	80
	MIN	16:35	40	50	19:36	17	50

Appendix C shows the maximum and minimum scores of each age that was tested within this study, and of both genders. This table is a minimized version of what is utilized to determine a soldiers APFT score. If a soldier scores less than the minimum score he/she fails the APFT. If a soldier scores higher than the maximum score on an event, it still counts as 100 points for that event. This information can be found in the US Army Field Manual 21-20 (FM 21-20), Headquarters, Department of the Army. FM 21-20 Physical Fitness Training.

APPENDIX D

Correlations

		12 Mile Ruck	2 Mile Run	2 Min Push Ups	2 Min Sit Ups
Pearson Correlation	12 Mile Ruck	1.000	-.654	-.165	-.188
	2 Mile Run	-.654	1.000	.327	.385
	2 Min Push Ups	-.165	.327	1.000	.769
	2 Min Sit Ups	-.188	.385	.769	1.000
	TOTAL	-.437	.742	.823	.871
	Age	.078	-.347	-.372	-.358
	Wgt	.579	-.595	-.156	-.124
	Hgt	-.008	-.233	-.251	-.249
	BMI	.771	-.605	.012	.024
	sex	-.066	.448	.168	.309
Sig. (1-tailed)	12 Mile Ruck	.	.002	.263	.235
	2 Mile Run	.002	.	.100	.064
	2 Min Push Ups	.263	.100	.	.000
	2 Min Sit Ups	.235	.064	.000	.
	TOTAL	.040	.000	.000	.000
	Age	.383	.086	.071	.079
	Wgt	.007	.006	.275	.318
	Hgt	.487	.184	.165	.167
	BMI	.000	.005	.482	.464
	sex	.400	.036	.259	.114

Correlations

		TOTAL	Age	Wgt	Hgt	BMI
Pearson Correlation	12 Mile Ruck	-.437	.078	.579	-.008	.771
	2 Mile Run	.742	-.347	-.595	-.233	-.605
	2 Min Push Ups	.823	-.372	-.156	-.251	.012
	2 Min Sit Ups	.871	-.358	-.124	-.249	.024
	TOTAL	1.000	-.443	-.387	-.311	-.263
	Age	-.443	1.000	.008	.014	.014
	Wgt	-.387	.008	1.000	.639	.737
	Hgt	-.311	.014	.639	1.000	-.042
	BMI	-.263	.014	.737	-.042	1.000
	sex	.400	-.010	-.489	-.499	-.241
Sig. (1-tailed)	12 Mile Ruck	.040	.383	.007	.487	.000
	2 Mile Run	.000	.086	.006	.184	.005
	2 Min Push Ups	.000	.071	.275	.165	.482
	2 Min Sit Ups	.000	.079	.318	.167	.464
	TOTAL	.	.038	.062	.112	.154
	Age	.038	.	.487	.479	.478
	Wgt	.062	.487	.	.003	.000
	Hgt	.112	.479	.003	.	.436
	BMI	.154	.478	.000	.436	.
	sex	.056	.484	.023	.021	.175

Correlations

		sex
Pearson Correlation	12 Mile Ruck	-.066
	2 Mile Run	.448
	2 Min Push Ups	.168
	2 Min Sit Ups	.309
	TOTAL	.400
	Age	-.010
	Wgt	-.489
	Hgt	-.499
	BMI	-.241
	sex	1.000
Sig. (1-tailed)	12 Mile Ruck	.400
	2 Mile Run	.036
	2 Min Push Ups	.259
	2 Min Sit Ups	.114
	TOTAL	.056
	Age	.484
	Wgt	.023
	Hgt	.021
	BMI	.175
	sex	.

Appendix D shows all correlations within data set. Pearson's correlation coefficient -1.000 – 1.000. $p \leq 0.05$.

APPENDIX E

Model Summary[i]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.863[a]	.744	.488	1215.041	
2	.863[b]	.744	.545	1145.553	
3	.861[c]	.741	.585	1093.283	
4	.860[d]	.739	.620	1046.407	
5	.852[e]	.725	.633	1027.896	
6	.840[f]	.705	.637	1022.733	
7	.806[g]	.650	.600	1073.219	
8	.771[h]	.595	.568	1116.288	1.855

a. Predictors: (Constant), sex, Age, BMI, 2 Min Push Ups, Hgt, 2 Mile Run, 2 Min Sit Ups, Wgt

b. Predictors: (Constant), sex, Age, BMI, Hgt, 2 Mile Run, 2 Min Sit Ups, Wgt

c. Predictors: (Constant), sex, Age, BMI, Hgt, 2 Mile Run, 2 Min Sit Ups

d. Predictors: (Constant), sex, Age, BMI, 2 Mile Run, 2 Min Sit Ups

e. Predictors: (Constant), sex, BMI, 2 Mile Run, 2 Min Sit Ups

f. Predictors: (Constant), sex, BMI, 2 Mile Run

g. Predictors: (Constant), BMI, 2 Mile Run

h. Predictors: (Constant), BMI

i. Dependent Variable: 12 Mile Ruck

Appendix E shows all model summaries provided by regression analysis.

APPENDIX F

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34310979.764	8	4288872.470	2.905	.076[b]
	Residual	11810605.766	8	1476325.721		
	Total	46121585.529	16			
2	Regression	34310954.098	7	4901564.871	3.735	.035[c]
	Residual	11810631.431	9	1312292.381		
	Total	46121585.529	16			
3	Regression	34168898.920	6	5694816.487	4.764	.015[d]
	Residual	11952686.609	10	1195268.661		
	Total	46121585.529	16			
4	Regression	34076938.871	5	6815387.774	6.224	.006[e]
	Residual	12044646.658	11	1094967.878		
	Total	46121585.529	16			
5	Regression	33442749.450	4	8360687.363	7.913	.002[f]
	Residual	12678836.079	12	1056569.673		
	Total	46121585.529	16			
6	Regression	32523807.766	3	10841269.255	10.365	.001[g]
	Residual	13597777.763	13	1045982.905		
	Total	46121585.529	16			
7	Regression	29996393.657	2	14998196.829	13.022	.001[h]
	Residual	16125191.872	14	1151799.419		
	Total	46121585.529	16			
8	Regression	27430092.544	1	27430092.544	22.013	.000[i]
	Residual	18691492.986	15	1246099.532		
	Total	46121585.529	16			

a. Dependent Variable: 12 Mile Ruck

b. Predictors: (Constant), sex, Age, BMI, 2 Min Push Ups, Hgt, 2 Mile Run, 2 Min Sit Ups, Wgt

c. Predictors: (Constant), sex, Age, BMI, Hgt, 2 Mile Run, 2 Min Sit Ups, Wgt

d. Predictors: (Constant), sex, Age, BMI, Hgt, 2 Mile Run, 2 Min Sit Ups

e. Predictors: (Constant), sex, Age, BMI, 2 Mile Run, 2 Min Sit Ups

f. Predictors: (Constant), sex, BMI, 2 Mile Run, 2 Min Sit Ups

g. Predictors: (Constant), sex, BMI, 2 Mile Run

h. Predictors: (Constant), BMI, 2 Mile Run

i. Predictors: (Constant), BMI

Appendix F shows an ANOVA provided by regression analysis. $p \leq 0.05$.