Improving the Aerobic Fitness Outcomes of U.S. Army Soldiers Deployed to Combat Zones

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On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy at the University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments, analysis and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, the University of Virginia, the Department of Defense, the Department of the Army, or by any other agency.

Table of Contents

Executive Summary

Operational variability and changing environments in combat zones and other conflict "hotspots" worldwide can preclude consistent physical training by U.S. Army soldiers while deployed to these locations. Limited or inconsistent aerobic exercise negatively impacts soldiers' cardiovascular endurance, potentially impacting their combat-readiness and health.

Army efforts to address physical fitness among deployed units are largely conducted at the discretion of individual base commanders with little more than Army Physical Fitness Test (APFT) standards and tradition guiding exercise regimens. Given the negative ramifications of diminished physical fitness on soldier health, troop readiness, recent direction from Secretary of Defense Jim Mattis to create "a decisive conventional force," the Army should take the opportunity to address this gap in its PT programming and improve cardiovascular endurance and aerobic fitness among soldiers deployed to combat zones.

Recommendation

This report analyzes three interventions in order to identify the most cost-effective means for Army to improve cardiovascular endurance among deployed soldiers in combat and conflict zones: promoting increased continuous moderate-intensity training (CMT) through use of personal wearable fitness devices (PWFD); replacing standard PT with a high-intensity tactical training (HITT) for deployed soldiers; and adapting the "Force Fitness Instructor" (FFI) model for deployed soldiers. After conducting a cost-effectiveness analysis and evaluating the three interventions against three qualitative criteria, this analysis recommends that the Army implement a HITT program to replace standard PT for soldiers deployed to combat zones.

I. Introduction

In his October 2017 memorandum for all Department of Defense (DoD) Personnel, Secretary Jim Mattis provided guidance on efforts to "enable us [DoD] to remain the world's preeminent fighting force." In this guidance, "military readiness" to "build a more lethal force" was listed as the primary line of effort with an emphasis on the need to field "a decisive conventional force" (Mattis, 2017). While follow-up public guidance from the DoD Office of Personnel and Readiness has only addressed the need to cut non-deployable forces [soldiers stationed domestically unable to meet fitness and/or health requirements for deployment], there has been growing concern about the ability of deployed personnel to remain in optimal combat-ready condition once stationed overseas (Pellerin, 2017).

Operational variability and changing conflict environments in combat zones and other conflict "hotspots" worldwide can preclude consistent physical training by U.S. Army soldiers while deployed to these locations. Limited or inconsistent cardiovascular exercise negatively impacts soldiers' cardiovascular endurance and general physical fitness resulting in an increased risk for injury, potentially resulting in failure of the APFT, and diminished combat performance. Injured, forcibly separated, or dead deployable soldiers impact force readiness and require replacement in theater [a "geographical area established… for the conduct of major operations and campaigns involving combat" (Department of Defense [DoD], 2017)]. The lack of standardized exercise regimens while deployed is enhanced by anecdotal reporting from Army commands regarding "concerns over increases in fat mass, decreases in lean mass, and decreases in strength following deployment" (Lester, Knapik, Catrambone, Antczak, Sharp, Burrell, & Darakjy, 2010).

Decreased engagement in aerobic exercise while deployed to combat zones has negatively impacted the cardiovascular endurance (as measured by VO_{2max}) and the perceived combat readiness of soldiers, potentially leading to negative ramifications on and off the battlefield. The Army must increase engagement in aerobic exercise of active-duty soldiers deployed to combat zones to ensure these forces remain combat-ready and in theater.

II. Background

A. The Army and Physical Fitness

This section provides background on deployment with the United States Army, constraints associated with physical fitness training while deployed, and the current state of physical fitness in the Army.

Deployment with the United States Army

As of 2017, there were more than 1.3 million United States military personnel on active duty, of which more than 200,000 were stationed overseas (Defense Manpower Data Center [DMDC], 2017). As the "primary land warfare component" of the U.S. military, the Army constitutes nearly a third of total active duty personnel and almost half of all personnel stationed abroad (The Heritage Foundation, 2017). Of 71,173 deployed active-duty soldiers, more than 20,000 are currently stationed in areas designated by Executive Order as "combat zones" where "U.S. Armed Forces are engaging or have engaged in combat" (Department of Defense [DoD], 2018b; IRS, 2017). A majority of deployed active duty soldiers are stationed in permanent bases in Germany and South Korea, while the largest combat zone contingents are in Afghanistan, Kuwait, and Iraq supporting ongoing conflict resolution and reconstruction efforts in the Middle East and Central Asia (IRS, 2017).

Policy options presented in this report will be applicable to soldiers located participating in DoD *Overseas Contingency Operations*, namely, Operation Freedom's Sentinel (OFS) in Afghanistan and Operation Inherent Resolve (OIR) in Iraq and Syria. In Afghanistan, soldiers are part of a larger DoD contingent executing "dual counterterrorism and train, advise, and assist missions supporting the Afghan National Defense and Security Forces" in their efforts to "secure more of the population from Taliban influence and control." DoD [including Army] engagements part of OIR are focused on countering the Islamic State of Iraq and Syria (ISIS) and "ensuring its defeat by consolidating gains and setting the conditions for a more stable region" by working "with… Iraqi and Syrian partners… to provide security in liberated areas, prevent the reemergence of the ISIS threat, and set conditions for long-term stability" (Office of the Undersecretary of Defense (Comptroller) Chief Financial Officer [OUSD], 2018).

Despite the closure of hundreds of bases in Iraq and Afghanistan since the height of U.S. engagement in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), the United States maintains approximately 800 bases in more than 70 countries and territories (Vine, 2015). When deployed to non-conflict areas, soldiers [and often times their families] live on "main operating bases" (MOBs), facilities "outside the United States and US territories with permanently stationed operating forces and robust infrastructure." These bases are "characterized by command and control structures, enduring family support facilities, and strengthened force protection measures" (DoD, 2018a). In combat zones, soldiers are stationed at "forward operating bases" (FOBs). While these bases are officially defined by the DoD as "an airfield used to support tactical operations without establishing full support facilities," they have evolved from "merely serving as a staging area for tactical operations" to becoming "the 'home away from home' for the American soldier" (DoD, 2018a & Wong & Gerras, 2006). Wong and Gerras note:

> *With over 100 FOBs in Iraq, conditions at each can vary greatly. On one extreme are the huge FOBs located near Baghdad International Airport that boast air conditioned sleeping and work trailers, cavernous dining facilities, spacious PXs [post exchange]…, cappuccino bars, well-stocked gyms, and Internet cafes. On the other end of the scale, some FOBs are located in old Iraqi Army bases or abandoned factories with soldiers still living in tents, food ferried from other FOBs, and more austere conditions. Overall, however, most soldiers in Iraq live on FOBs somewhere in the middle range—air conditioned quarters, a small PX, a MWR facility with Internet and phone lines, and a contracted dining facility.* (2006)

While stationed at FOBs, soldiers often do rotations out to combat outposts and patrol bases, small locations with fewer amenities than FOB. Almost all of these facilities lack gyms, air conditioning, permanent structures, and other amenities found at MOBs or FOBs (Fallowfield, Delves, Hill, Cobley, Brown, Lanham-New, & Allsopp, 2014).

Deployments to combat zones are typically one year, but can range in length from six to 18 months (Nindl, Jones, Van Arsdale, Kelly, & Kraemer, 2016). As of 2010, active-duty soldiers averaged 1.76 deployments to Iraq and Afghanistan with a mean deployment length of approximately 9.5 months. Soldiers considered "multiple deployers" averaged a cumulative deployment length of 22.66 months, with 20.37 months of "dwell time" in between deployments on average (Institute of Medicine, 2013). Deployments in support of OEF and OIF were "portrayed as long and repeated" (Talbot, Weinstein, & Fleg, 2009). There is no published data with more recent information on mean number and length of deployments as part of OFS or OIR, but we have no reason to suspect that current deployment environments differ significantly from previous ones.

Army Guidance on Physical Training

A physically fit military is the "strongest asset" a state has in national defense (Jonas et al., 2010). Although many members of the military are believed to be the epitome of fitness, a recent survey showed that 16.1 percent of soldiers older than 20 years of age are overweight or obese according to their body mass index (BMI) (DoD, 2013). Addressing the concern of an overweight workforce and general need for a combat-ready military, physical training (PT) and fitness are required components of military employment.

Army Field Manual (FM) 7-22 "Army Physical Readiness Training" (PRT) serves as the branch's official PT doctrine. FM 7-22 details the Army's philosophy on physical fitness in addition to prescribing specific types and schedules for PT to be conducted at various stages of a soldier's career. Training should occur in both unit and individual settings and commanding officers (COs) should provide soldiers with the knowledge needed to conduct individual PT in addition to "encourage[ing] and motivate[ing] Soldiers to accept individual responsibility for their own physical readiness" (Department of the Army [Army], 2013). COs provide resources and support programs that improve or maintain every Soldier's physical readiness and require mandatory participation. While PRT is focused primarily on PT for soldiers stationed domestically, the document notes the importance of training while deployed as "vital to mission success… despite personnel turbulence and operational deployments" (Army, 2013).

Physical Training While Deployed

According to PRT guidelines, "every effort should be made by leaders to conduct PRT activities as often as mission requirements allow during deployment." Enforcement of fitness standards during deployment is "at the commander's discretion," but "fitness programs [should] be maintained while deployed to keep soldiers combat ready" (Lester et al., 2010). Training while deployed is considered a "sustaining phase" training designed to maintain the degree of fitness achieved pre-deployment. Units should continue PT activities "safe and appropriate" to their base and operating environment and soldiers should "become experts in the conduct and performance" of PT (Army, 2013).

When training domestically (or at large main operating bases like those in Germany, Italy, and South Korea) physical fitness training equipment and workout offerings are extensive. Soldiers have access to gyms with a diversity of equipment and safe areas to run both in and outside of base (TRX, 2017). "Time is set aside during the day for mandatory job exercise sessions" when stationed at these locations and the majority of organized PT is spent running to "meet or beat" APFT guidelines (The Tactical Meathead, 2011). However, these conditions are not shared in combat zones despite PRT guidance dictating that training equipment (like treadmills) be made available when operating conditions limit the availability of safe training environments.

Most FOBs have relatively rudimentary gyms with some cardio equipment and an area to jog, patrol bases and combatant outposts lack both safe environments to conduct long-distance aerobic exercise and the aerobic equipment necessary conduct exercise indoors. At patrol bases and combat outposts, most cardiovascular exercise is achieved by conducting foot patrols (Nelson, 2007). "Forward operating bases and patrol bases remain austere living and working environments" despite improvements made in recent years (Fallowfield et al., 2014). The lack of ideal or secure conditions for aerobic exercise is consistently referenced by soldiers as an issue at these locations while deployed in combat zones (Company Commanders, 2006).

Constantly changing operational environments and mission requirements also pose a challenge to engaging in consistent aerobic exercise. Soldiers have to conduct scheduled foot patrols, unplanned raids, and more in the field - no two days are necessarily alike. The conventional mass field training approach (mandatory group PT, designated weight room time, etc.), while "easy to plan and implement when training large groups of soldiers" and used extensively on domestic bases, does not allow for adaptation based on changing environments (Nindl et al., 2016). Due to this, units typically conduct limited organized PT while deployed to combat (Gourley, 2015). One CO noted the difficulty of blending training with daily operations, other "worst-case scenarios" and the "greatly differing physical capabilities" between younger and older, fitter and less fit soldiers (The Tactical Meathead, 2011). Some COs do enforce limited mandatory group PT to ensure soldiers are acclimated to extreme climates ahead of the Army Physical Fitness Test – the service's assessment of physical fitness in soldiers (Military Friends of NewsBlaze, 2009). However, judging from a body of first-hand accounts from COs, this is not the norm for weekly PT, especially at smaller bases or postings.

With respect to individual PT, soldiers remain responsible for completing conditioning while deployed in combat zones. Anecdotal reporting suggests soldiers dedicate the majority of this PT to weightlifting and other strength training instead of aerobic conditioning. This reporting tracks with studies of decreased aerobic activity in soldiers deployed to Iraq and Afghanistan as part of OIF and OEF. Prior to deployment to Iraq, 80 percent of soldiers engaged in aerobic exercise three or more days a week and 78 percent performed this exercise for more than 30 minutes "per session." During a 13-month deployment, only 35 percent of soldiers engaged in aerobic exercise at the same weekly frequency (a 44 percent decrease), while engagement for more than 30 minutes decreased by 22 percent to 57 percent of soldiers. No significant change was reported regarding the frequency of strength training and engaging in sports activities (Sharp, Knapik, Walker, Burrell, Frykman, Darakjy, & Marin, 2008). Similar results were found among soldiers deployed as part of OEF. While in Afghanistan, the proportion of soldiers who performed aerobic exercise at least three times a week decreased by a significant 61 percent from pre-deployment levels. The proportion of soldiers during the 9-month deployment who "performed aerobic exercise for at least 30 minutes per session" decreased a significant 44 percent from pre-deployment levels (Lester et al., 2010).

Implications of Deployment for Soldier Fitness and Body Composition

Studies of soldiers in OEF and OIF suggest the extent to which deployments to combat zones affect soldier aerobic fitness and body composition.

A 2007 study of soldiers following a 9-month deployment to Afghanistan during OEF found that soldiers experienced an increase in fat mass, a decrease in cardiovascular endurance, and a decrease in self-ratings for physical fitness. The average body weight of soldiers in the study decreased by approximately three pounds. However the loss came from lean muscle mass –soldiers gained a statistically significant 2.6 pounds of fat mass on average. Physical fitness tests "showed reductions in aerobic fitness and upper body strength, but lifting and lower body strength remained unaffected" – consistent with foot patrols and physical labor on base in Afghanistan. Peak VO_2 output – a measurement "generally considered the best indicator of cardiovascular fitness and aerobic endurance" (Exercise Physiology Core Lab, n.d.) - decreased a statistically significant 4.5 percent during deployment, from 50.8 to 48.5 $mL \cdot kg^{-1} \cdot min^{-1}$. It is important to note that the decrease in average VO_{2max} and increase in fat mass noted were likely not the result of a lack of exercise equipment: ninety-one percent of the soldiers in Afghanistan had aerobic equipment available to them and 95 percent had access to strength training equipment. Instead, these changes are likely the result of the previously noted decreased engagement in aerobic exercise.

A similar study in 2010 evaluated changes in physical fitness and body composition among soldiers following a 13-month deployment to Iraq. Evaluated along the same metrics as soldiers in the Afghanistan study, soldiers in Iraq experienced statistically significant increases in both upper and lower body strength, gains in lean and fat mass, and decreases in cardiovascular endurance. Upper body strength increased by seven-percent while lower body strength increased by eight-percent. Average body weight increased by 2.9 percent, while the mean body fat percentage increased by 4.2 percent, on average. Peak VO_2 output decreased a statistically significant 12.3 percent during deployment. Researchers attributed this decrease in cardiovascular endurance to the previously noted decrease in aerobic training volume (Lester et al., 2010).

A similar decrease (11.0 percent) in aerobic capacity was found in soldiers deployed to *both* Iraq and Afghanistan for 11 months, potentially suggests deployment to Iraq is a greater contributor to decreased aerobic capacity, however there have been no studies to that effect (Warr, Heumann, Dodd, Swan, & Alvar, 2012). Disparities in physical fitness and body composition outcomes between the two cohorts can likely be explained by differences in combat experience: soldiers in Iraq visited the gym to lift weights, while troops in Afghanistan exercised less frequently due to long, strenuous foot patrols with heavy combat loads (Gourley, 2015).

While the post-deployment VO_{2max} values still identify soldiers as being “good” in most categorizations of VO_{2max} values - albeit at the lower end of the “good” range – the average decrease of 8.35 percent across studies suggest soldiers are at increased risk of diminished performance in combat and an increased risk of cardiovascular disease and other health problems (*American Council Exercise Personal Trainer Manual 2nd Edition*, n.d., & VO2 Max, 2018).

Importantly, the specific changes exhibited by American soldiers appear to be relatively unique when compared to foreign forces deployed in similarly austere conditions. A study of Finnish Defence Forces deployed to Chad “observed 4 and 10 % losses in body mass and fat mass, respectively, and no changes in strength…or endurance” (Rintamäki, Kyröläinen, Santtila, Mäntysaari, Simonen, Torpo, & Lindholm., 2012). Research on the body composition and physical fitness of British Royal Marines during a 6-month deployment to Afghanistan found that fat mass decreased while Marines maintained levels of aerobic fitness (as indicated by VO_{2max} measurement) during the deployment. Like their American counterparts, Royal Marines improved performance in designated measures of muscle strength. No significant changes in aerobic PT or sports-activity were noted, suggesting aerobic conditioning exercise was maintained among Royal Marines (Fallowfield et al., 2014).

B. Importance of Aerobic Exercise for Soldiers

Commanding officers suggest that a loss of lean muscle mass and cardiovascular endurance as a result of decreased aerobic training could have potential negative effects on mission performance and readiness in addition to long-term ramifications for soldiers and the military (Sharp et al., 2008).

Cardiovascular Health

Cardiovascular disease (CVD) is the leading cause of noncombat-related admission to combat support hospitals, hospitalization for infectious diseases (Sullenberger & Gentlesk, 2008). The rate of soldiers exhibiting cardiovascular symptoms in-theater - including myocardial ischemia (a common precursor to heart attacks), syncope (fainting), and arrhythmia (palpitations) - has increased from previous conflicts. Soldiers deployed in combat zones were 1.33 times more likely than non-deployers and 1.02 times more likely than deployers with no-combat experience to develop CHD, suggesting the unique effects of combat deployment on cardiovascular health (Crum-Cianflone, Bagnell, Schaller, Boyko, Smith, Maynard, & Smith, 2014). While cardiovascular symptoms are typically observed in older individuals with a higher risk of CVD, young soldiers experienced similar symptoms in the "stressful combat environment." Diminished physical fitness "coupled with the protracted stress of combat operations place soldiers at greater cardiovascular risk during deployment and war" (Talbot et al., 2009). Of service members deployed to combat zones, six percent develop hypertension and approximately one percent develop coronary heart disease during deployment (Crum-Cianflone et al., 2014 & Granado et al., 2009). While these rates are lower than would be expected among a civilian population, these soldiers were otherwise not at risk [or at very low risk] for CVD save for deployment.

Aerobic fitness and cardiovascular endurance is consistently associated with a decrease in risk of CVD, predominately in CHD and hypertension (high blood pressure). A longitudinal study of 522 male civilians demonstrated that high levels of cardiovascular fitness – as indicated by VO_{2max} levels – predicted a decreased risk of observed 10-year CVD events (Talbot, Morrell, Metter, & Fleg, 2002). A study of men in the U.S. Navy found that those with higher levels of cardiovascular fitness (as indicated by VO_{2max} levels) had lower blood pressure (Macera, Aralis, MacGregor, Rauh, Han, & Galarneau, 2011).

Body Composition

Increases in fat mass experienced by soldiers in both the Iraq and Afghanistan studies are congruent with "previous studies of individuals who run as their primary means of aerobic training" (Lester et al., 2010). These studies reported increases in body fat when training was reduced or stopped. If aerobic training stops completely, there are further implications for VO_{2max} levels. Previous studies have found that one month in which there is a 90 percent decrease in cardiovascular exercise results in a 21 percent decrease in cardiovascular endurance (Madsen, Pedersen, Djurhuus, & Klitgaard, 1993).

Combat Readiness

Individual soldiers are a critical component of their teams and units. "One soldier's condition can cause dramatic changes to operational plans because of the ill or injured soldier's inability to perform the mission" (Nindl, Castellani, Warr, Sharp, Henning, Spiering, & Scofield, 2013). A post-deployment survey of soldiers who served in Iraq and Afghanistan found that the majority of tasks associated with physical combat readiness predominantly relied upon aerobic fitness and endurance (Jacobson, Horton, Smith, Wells, Boyko, Lieberman, & Millennium Cohort Study Team, 2012). Units have the incentive to prevent injuries and illness among soldiers to both keep individuals from suffering and from negatively affecting operations and mission readiness. Among soldiers, higher VO_{2max} levels have been associated with decreased "medical resource utilization." Additionally, soldiers who experienced the "sharpest declines" in VO_{2max} "had significantly more medical visits over the course of the deployment" (Warr et al., 2012).

C. Previous Approaches to Improving the Physical Fitness & Cardiovascular Endurance of Military Personnel

There are no readily-available examples of Army – or other service – interventions to improve the physical fitness or cardiovascular health of active-duty deployed soldiers. However, a plethora of formal and informal programs designed to improve these characteristics in military personnel stationed domestically or among members of the National Guard provide insight into potential solutions for improving cardiovascular endurance among deployed soldiers.

A 2006 informal report on expeditionary fitness by company commanders detailed various approaches to maintaining combat readiness during deployment "given the reality of 24-operations in harsh environmental conditions, a non-secure environment, and the length of... deployment cycles." When COP lacked adequately secure areas to conduct cardio training, commanders often sent platoons back to FOB to "refit" and conduct mandatory cardio PT sessions at the squad level for two days per week while others said that patrols provided intensive cardio workouts. One commander noted that dedicated PT required "squad-level execution with platoon-level planning." A lack of dedicated time for PT and exhaustion due to combat operations also constrained cardiovascular exercise (Company Commanders, 2006).

In 2011, the United States Marine Corps (USMC) introduced High-Intensity Tactical Training (HITT) as an enhancement to their existing "Semper Fit" functional-strength program designed to prepare Marines for combat. Based on a "CrossFit" model, HITT workouts are one hour in length and built around five components: injury prevention, strength and power, speed and agility, core stability and flexibility, and nutrition. Initial workouts are supervised by Marines designated as Strength and Conditioning Specialists and then incorporated into daily PT regimens (Steinbach, 2011).

In 2013, U.S. Army initiated two exercise intervention programs to improve the physical fitness of Army National Guard (ARNG) soldiers who had previously failed the 2-mile-run section of the APFT – a traditional program with an ARNG Master Trainer and "Fitness for Life" - a pedometer-based program with individual counseling and follow-up phone calls. In both interventions, the participants were briefed with training booklets before the intervention was initiated where soldiers were involved in group training sessions and individual exercises. Effectiveness of the two interventions was measured by assessing APFT pass rates and 10-year risk of coronary heart disease. There was no statistically significant difference in the effectiveness of the two programs in increasing pass-rates on the APFT and there was no difference in the risk of coronary heart disease in either program. While the pedometer-based Fitness for Life Program "was more expensive and thus less cost-effective, either program could be cost effective and of benefit to the military" (Talbot et al., 2013).

The Army also launched its Performance Triad program in 2013 to improve soldiers' nutrition, activity, and sleep habits as part of broader Army efforts to combat growing obesity rates within the service (Bushatz, 2013). As part of initial battalion trial programs, the Army created a smartphone application and issued Fitbit Flex personal wearable fitness devices to more than 2,200 soldiers to assist individuals in tracking their activity, sleep, and nutrition. While no official results were made publicly available, soldiers reportedly increased activity when given a goal for number of steps taken per day, days of resistance training, and a target of 150 minutes or more per week of moderate aerobic exercise. The program was expanded to 20,000 Army personnel stationed domestically (Lilley, 2015).

In 2016, the United Kingdom's Ministry of Defence (MoD) supplied Fitbit devices (unspecified version/type) to overweight soldiers at risk of discharge for failing to meet physical fitness test standards. The MoD also hired private fitness instructors to train groups of overweight soldiers (Mathews, 2016).

Also in 2016, the USMC announced the creation of a "force fitness instructor" military occupational specialty to serve as physical fitness experts for commandants. Force fitness instructors will use "the latest in scientifically-based techniques, modern technology, and the sports medicine field" to design a physical fitness program "focused on optimizing performance, increasing durability, and maximizing [combat] readiness" for their units and assist the unit in implementation (Panzino & Bacon, 2016) (United States Marine Corps, n.d.). Instructors were assigned to Marine expeditionary forces and other commands.

D. General Methods for Improving Cardiovascular Endurance in Adults

Improving cardiovascular endurance in adults requires increased engagement in aerobic exercise. Aerobic exercise is designated low-intensity, medium-intensity, or high-intensity based on an individual's exertion level (measured by heartrate) during the exercise. The American Heart Association and the Centers for Disease Control and Prevention define low-intensity aerobic exercise as 40-50 percent of an individual's max heartrate, moderate-intensity as 50-70 percent, and high-intensity as 70-80 percent (Akbari Kamrani, Shamsipour Dehkordi, & Mohajeri, 2014 & Mayo Clinic Staff, 2017). Mayo Clinic guidelines suggest that adults should "aim for at least 150 minutes of moderate aerobic activity or 75 minutes of vigorous aerobic activity a week, or an equivalent combination of moderate and vigorous activity" (Laskowski, 2016).

According to PRT guidelines, an ideal endurance training program balances both anaerobic (high intensity and short duration) and aerobic (low-medium intensity and long duration) training to prepare soldiers for a wide variety of operational tasks. A combination of "speed running, sustained running, and foot movement under load must be performed." Endurance programs emphasizing only long-distance running "fail to prepare units for the type of anaerobic endurance they will need for the conduct of full spectrum operations" (Army, 2013).

Increased moderate-to-high intensity aerobic exercise has been shown to improve cardiovascular endurance and reduce CVD risk. The following methods have been shown to increase aerobic exercise frequency and/or cardiovascular endurance: increasing moderate-intensity continuous training, incorporating high-intensity interval training into existing exercise programs, using a personal wearable fitness device, and using a personal trainer.

Increasing Continuous Moderate-Intensity Training (CMT)

CMT is what most individuals think of as aerobic exercise and is performed for at least 30 minutes. When "sustained for 30 minutes or more," CMT "has been traditionally recommended for hypertension prevention and treatment" (Ciolac, 2012). Consistent engagement in moderate-intensity exercise has been associated with reduced incidence of Type II Diabetes, increased HDL ("good") cholesterol, lowered LDL (bad) cholesterol, and decreased BMI (Swain & Franklin, 2006).

Examples of CMT include running (jogging), cycling, swimming, and hiking. For the purposes of this report, running will be assumed the CMT of choice as it is the exercise most easily translated to a combat zone environment (Haddock, Poston, Heinrich, Jahnke, & Jitnarin, 2016 & Schjerve, Tyldum, Tjønna, Stølen, Loennechen, Hansen, & Wisløff, 2008). Running requires no additional equipment and is a "highly aerobic activity" excellent at "conditioning the cardiovascular system" (Cantwell, 1985).

Adopting High-Intensity Interval Training (HIIT)

HIIT workouts have become increasingly popular in recent years, and are now the “leading trend in the fitness industry” according to the American College of Sports Medicine (Haddock et al., 2016). HIIT “describes physical exercise that is characterized by brief, intermittent bursts of vigorous activity, interspersed by periods of rest or low-intensity exercise” and typically take no more than thirty- to fifty-minutes to complete (Gibala, Little, MacDonald, & Hawley, 2012). HIIT workouts are designed to address total-body fitness, improve aerobic capacity, and strengthen muscles.

A subcategory of HIIT is high-intensity tactical training (HITT), which is also known as high-intensity functional training (HIFT). This type of training emphasizes the skills, fitness dimensions, and “functional movements” necessary to perform well in combat or other operational environments. HITT “stresses both aerobic and anaerobic energy pathways and is balanced in addressing power, strength, flexibility, speed, endurance, agility and coordination” (Haddock et al., 2016).

HITT workouts have been noted as “useful in deployed environments where traditional fitness centers and equipment may not be available.” Training is “typically between 25% to nearly 80% less than traditional military fitness programs… without reductions in fitness outcomes” (Haddock et al., 2016).

Use of Personal Wearable Fitness Devices (PWFD)

PWFD have become increasingly popular since the 2009 introduction of the Fitbit Classic device, the introduction of the Fitbit One in 2012, and the 2015 introduction of the Apple Watch. General usage of all PWFD increased by 449.33 percent between 2012 and 2017 judging from market data, mirroring trends in other personal electronic devices (PEDs) (Statista, 2018). Nearly half of all these users are young and health conscious – 48 percent of the current PWFD market share is occupied by 18-34-year-olds and a majority of fitness device users “said the ability to self-monitor [exercise] was a major factor” in their use of the devices (Nielson, 2014). These small technological devices have the ability to track and monitor distance walked, cycled, or run, calories consumed, heart rate, and other bio- and fitness metrics. PWFD are wirelessly connected and synced to computers and smartphones that run applications to track data over time (Kaewkannate & Kim, 2016). PWFD are touted as easy ways to increase awareness about physical activity and improve fitness, however there are conflicting studies regarding the benefits of device usage.

Most literature addresses the step-counting or pedometer aspect of PWFD: the use of pedometers to track steps (with an aim of approximately 10,000 steps per day) is “associated with significant increases in physical activity and significant decreases in body mass index and blood pressure” (Bravata, Smith-Spangler, Sundaram, Gienger, Lin, Lewis, & Sirard, 2007). Pedometer-based fitness programs “have been shown to significantly increase the amount and intensity of PA [physical activity], and to decrease blood pressure (BP) and body mass index (BMI). Using a pedometer to accumulate moderate-to-high intensity PA in short bouts improves cardiovascular fitness" (Talbot, 2011). Findings in a study of U.S. military medical students suggest that those who "consistently report meeting the 10,000 steps/day maintained or improved their aerobic fitness" while a study of Finnish military-aged men found that "the use of a wrist-worn physical activity monitor providing feedback of activity has a short-term positive effect on measured daily physical activity" and self-reported physical activity (Lystrup, West, Ward, Hall, & Stephens, 2015 & Jauho, Pyky, Ahola, Kangas, Virtanen, Korpelainen, & Jämsä, 2015). PWFD allow for self-monitoring and gauging of fitness progress and activities by providing feedback to the user. Device feedback and rewards, in addition to other behavioral "change techniques [are] closely tied to goal setting that can be effective for increasing activity." These effects can be enhanced through social support and competition (Sullivan & Lachman, 2017).

III. Methodology

As noted, soldiers return from deployment to combat zones with decreased cardiovascular endurance and aerobic fitness, both of which negatively affect soldier health and combat-readiness of troops. This problem is, in part, due to decreased engagement in aerobic exercise. The following sections of this report will develop and evaluate interventions that the U.S. Army could use to improve the cardiovascular endurance and aerobic fitness of soldiers deployed to combat zones. An ideal intervention will improve engagement with aerobic exercise while minimizing negative security and health externalities and costs. First, both quantitative and qualitative evaluative criteria are presented. Then, policy interventions are described and assessed based on these criteria. Finally, a recommendation is made and the implementation of an intervention is described while providing the Army with additional areas for further consideration in improving cardiovascular endurance and aerobic fitness of soldiers deployed to combat zones.

IV. Evaluative Criteria

Policy interventions will be proposed and evaluated in comparison to the status quo as detailed on page 29. Interventions must take into consideration the constantly changing environment of, associated security concerns with, and best practices for conducting PT in combat zones.

All interventions and associated estimates assume the deployment of **20,184 soldiers** to combat zones in support of Overseas Contingency Operations (OCO). OCO encompasses ongoing military operations in Syria, Iraq, and Afghanistan. This number reflects the increase in troops supported by the Trump administration and there will likely be no change to this number barring any major change in U.S. foreign policy (DoD, 2018b).

To efficiently allocate limited U.S. Department of Defense resources, military fitness programs need to train units of soldiers with fewer dollars while improving health and fitness outcomes (Talbot, 2013). Programs will be judged along the following criteria to evaluate their effectiveness in achieve this goal:

1. Cost
2. Effectiveness
3. Cost-Effectiveness
4. Minutes of Exercise Required Per Week
5. Injury Rate
6. Likelihood of Incentivizing Individual Participation
7. Security Risks

Cost

Costs will be measured in dollars and include material and personnel expenditures required to develop and implement proposed interventions. Costs incurred after the first year of implementation will be subject to simple, annual discounting at the Office of Management and Budget suggested discount rate of **7 percent** (2003).

Material costs include the cost of printing any documents required to facilitate an intervention and the purchase of any necessary equipment. Material costs have been derived from industry standards and market prices as appropriate. The industry standard for black and white printing or copying is **$0.07 per page** (Talbot et al., 2013).

Personnel costs will be measured by salary, support, and maintenance expenditures necessary to execute a program. Existent personnel deployed to combat zones are not considered in this cost-effectiveness analysis. Military personnel salaries have been taken from the 2018 Military Basic Pay Scale. Time spent conducting PT while working will not be calculated as lost productivity among soldiers given that PT is a job requirement.

Training time during leisure hours will also not be calculated as lost productivity.

The average direct cost of maintaining a soldier in a combat zone - including salary - is **$185,397**, based on the FY19 Defense Budget Requests for OCO (DoD, 2018b & Army, 2018). This request encompasses all military personnel supporting operations in Syria, Iraq, and Afghanistan. Personnel salaries, benefits, support, and maintenance are categorized as "Military Personnel" and "Operations and Maintenance." This expenditure is not individual-dependent and does not change based on the individual in theater.

Effectiveness - Change in VO_{2max}

This criterion will project the estimated effect of each proposed intervention by measuring the estimated percentage point change in VO_{2max} experienced by the average soldier. This measure estimates the extent to which an intervention improves the 8.35 percent decrease in VO_{2max} experienced by soldiers deployed to combat zones. The greater a percentage point increase in VO_{2max}, the more the decrease currently experienced by soldiers will be mitigated. VO_{2max} was chosen as the outcome of interest as it is the best indicator of aerobic fitness and cardiovascular endurance in addition to being "predictive of cardiovascular" disease and mortality (Kravitz, 2014).

This measure is discounted by an industry standard seven percent discount rate to "account for uncertainty of future outcomes" (Childress, 2017). Outcome estimates are based on previous studies of exercise effects on VO_{2max}. Studies of military personnel have been used when possible to account for possible confounding variables.

Cost-Effectiveness

This criterion will evaluate the "return on investment" of a given intervention (Childress, 2017) and will be reported as the cost per additional percentage point of VO_{2max} gained. Proposed interventions will be treated and evaluated as five-year programs implemented across the more than 20,000 active-duty soldiers deployed to combat zones.

Cost effectiveness estimates and assumptions are detailed in Appendices A and B.

Minutes of Exercise Required Per Week

Interventions should minimize the amount of time necessary to complete PT. Soldiers have limited and highly variable leisure time while deployed to combat zones due to changing mission requirements and operational environments. These time constraints, coupled with the need for soldiers' to rest and recuperate, suggest that interventions should require little to no additional time outside of a soldier's daily scheduled PT and work hours.

Proposed interventions will be measured according to the minutes of exercise required per week.

Injury Rate

Interventions should avoid increasing the current status quo injury rate if possible. Injury rates for proposed interventions will be projected based on rates observed in research. Projected injury rates are assumed to replace the status quo injury rate as soldiers will be replacing their current exercise regimen with the proposed intervention.

Likelihood of Incentivizing Individual Participation

Current PRT guidelines suggest a combination of both group and individual PT responsibilities and any potential program should incorporate both elements of a PT plan. However, a combined plan must include flexibility should mission requirements prohibit units from executing group fitness programs. In this instance, "individual fitness programs should be encouraged and, to the extent possible, enforced" while also "designed to improve the individual's contribution to the unit's physical readiness" (Lester et al., 2010) (Army, 2013). Successful programs should incentivize individual participation and adherence.

Proposed interventions will be ranked according their likelihood of incentivizing individual participation and scored as follows:

Very unlikely to incentivize individual participation
Unlikely to incentivize individual participation
No effect on incentives for individual participation
Moderately Likely to incentivize individual participation
Very likely to incentivize individual participation.

Security Risks

This criterion measures the potential impact on personal and operational security. This impact will be measured by evaluating the extent to which violations or the use of PWFD will increase or decrease the ability of adversaries to discover the patterns of life and locations of military personnel.

PT programs should not place soldiers or military installations at risk of being compromised. Many FOBs, combat outposts, and patrol bases are located in areas that are unsafe outside of a secured perimeter. Care should be given to maintain or improve upon current personal security and operational security measures. Personal security refers to preventing the discovery of personal information that if compromised could result in the harm of an individual. Operational security refers to identifying and controlling "critical information" and "actions attendant to military operations" while incorporating "countermeasures to reduce the risk of an adversary exploiting vulnerabilities" (DoD, 2018a). PT programs should not degrade the personal security of individual soldiers nor the operational security of a given mission.

Alternatives will be scored on this criterion as follows:

> **High Risk –** Very Likely to Worsen Security: Alternative greatly or completely improves the ability of adversaries to fully identify the patterns of life and locations of military personnel as compared to the status quo.
>
> **Medium Risk –** May Slightly Worsen Security: Alternative partially improves the ability of adversaries to fully identify the patterns of life and locations of military personnel as compared to the status quo.
>
> **Low Risk** – Unlikely to Affect Security: Alternative has no impact on the ability of adversaries to fully identify the patterns of life and locations of military personnel as compared to the status quo.

V. Status Quo

Status Quo

In the status quo, the Army maintains its current PT structure for active-duty soldiers deployed to combat zones. This structure allows individual soldiers to largely self-determine what type of PT to engage in and how often to complete the training. PT requirements beyond those prescribed by the APFT and training regimens remain at the discretion of base commanders. Commanding officers retain their ability to determine the appropriate amount and type of PT for units, based on given operational and mission requirements.

Effectiveness – Change in VO_{2max}

In the status quo, effectiveness isn't measured. Instead, the change in VO_{2max} is a byproduct of deployment. According to the three studies of soldiers stationed in combat zones, in the status-quo soldier **VO_{2max} decreases by an average of 8.35 percent (-8.35%) during deployment to combat zones.**

Cost & Cost Effectiveness

There are **no additional costs** in the status quo as the existing program of exercise will continue until an intervention is chosen or in the instance an intervention is not chosen.

Minutes of Exercise Required Per Week

Soldiers deployed to combat zones currently exercise for a total of approximately **69 minutes of aerobic exercise per week** (Sharp et al., 2008 & Lester et al., 2010).

Injury Rate

A study of "Non-battle injuries among U.S. Army soldiers deployed to Afghanistan and Iraq, 2001–2013" found that approximately 20 percent of soldiers noted experienced a non-battle related injury (Patel, Hauret, Taylor, & Jones, 2017). A second epidemiologic study of non-battle related injuries found that approximately 23.35 percent of these injuries were PT- or sports-related (Skeehan, Tribble, Sanders, Putnam, Armstrong, & Riddle, 2009). Combining these findings, approximately **five percent of all Army personnel deployed experienced a PT-related injury.**

Likelihood of Incentivizing Individual Participation

As noted in the background, most soldiers currently do not prioritize aerobic training if and when they conduct PT, instead favoring strength training. Maintenance of the status quo is **unlikely to incentivize individual participation**.

Security Risks

Maintenance of the current PT regimen **low risk** and unlikely to affect security.

VI. Proposed Intervention Options

Option 1: Promote Increased CMT through Use of PWFD [CMT + PWFD]

The Army will promote increased aerobic exercise, namely CMT, through the use of PWFD. This intervention is similar to a previously tested *Fitbit* distribution program and other pedometer-use programs and soldiers will be instructed to reach at least 10,000 steps per day while using the device. Soldiers would be responsible for tracking their exercise with the devices and adhere to guidance provided in information manuals distributed upon arrival to combat zones. COs will collect weekly reports from soldiers to track and evaluate troop fitness and take appropriate disciplinary action should a soldier fail to get enough aerobic exercise.

The Army previously partnered with *Fitbit* to provide devices to soldiers stationed domestically and will again purchase devices from the company.

Cost

The costs for this intervention can be accounted for by the direct costs of purchasing and supporting the use of PWFD by soldiers and the printing costs of providing an information manual for soldiers.

The *Fitbit Flex2* is the lowest cost PWFD sold by *Fitbit* that also meets Army uniform guidelines and is $59.99 per device (Fitbit, 2018). Approximately 10 percent of soldiers deployed to combat zones likely already possess a PWFD (Riley, 2015), suggesting 18,166 soldiers [of the 20,184 deployed to combat zones] will need to be provided with a *Flex2* device. For the purposes of this estimate, it has been assumed that devices will not need replacement, or that any necessary replacement will be covered under the manufacturer's warranty. The distribution of *Flex2* devices to soldiers deployed to combat zones will cost $5,495,628.30 over five years.

The *Flex2* device must be paired to a smartphone or iPod Touch via a Bluetooth connection. While most soldiers will possess either a smartphone or iPod touch, consumer trends suggest that five percent, or 1,009 soldiers, will not possess either device (Smith, 2017). Given that they are cheaper than smartphones, the Army will provide iPod Touch devices to these individuals who do not have either a smartphone or an iPod Touch to ensure that the *Flex2* device can be used. iPod Touch devices currently retail for $199.00 per device (Apple, 2018) and will cost $1,012,789.20 over five years.

A 95-page training manual will be produced and distributed to every soldier deployed to combat zones. At an industry standard of $0.07 per page copied, each manual will be $6.65 and will cost $676,889.26 over five years.

The total cost for this intervention is **$7,185,306.76** over five years**.**

Effectiveness – Change in VO_{2max}

A study of two CMT interventions in "moderately-trained males" found that an increase of CMT increases VO_{2max} by an average of **2 percentage points**, which would reduce the 8.35 percent decrease to a 6.35 percent decrease (Helgerud et al., 2007).

As a note, there is extensive literature supporting greater increases in VO_{2max} resultant from increasing CMT that would present an even more compelling argument for its use to improve cardiovascular endurance among soldiers deployed to combat zones. However, these studies have focused almost exclusively on improving the fitness and cardiovascular endurance of sedentary and non-athletic individuals. Deriving estimates of increases in VO_{2max} from these studies would be inappropriate in an application to highly-athletic and trained soldiers where "lower improvement in VO_{2max} at higher fitness levels" is expected (Helgerud et al., 2007).

Cost-Effectiveness

Given the estimates above, the cost-effectiveness of maintaining the CMT with PWFD program for five years is projected to be about **$712,404.37** per percentage point gained in VO2max.

Minutes of Exercise Required Per Week

While there have been no formal studies of PWFD use to increase the time spent engaged in exercise, a pedometer-based fitness intervention in Army National Guard Soldiers found that the use of pedometers was associated with a 70 percent increase in moderate-intensity aerobic exercise (Talbot et al., 2011). Assuming this same increase will be found upon adoption of PWFD to increase CMT, soldiers will be conducting approximately **117 minutes of aerobic exercise per week**.

Injury Rate

As noted, CMT increased through the use of PWFD will be predominately distance running. The injury rate associated with increased distance running among male military recruits has been noted as 15-20% - the lower bound of this range is accepted as soldiers deployed in combat zones are more physically fit and less injury prone (Poston, Haddock, Heinrich, Jitnarin, & Batchelor, 2016). Therefore, this intervention will increase the injury rate from five percent to **15 percent,** an increase of 200 percent.

Likelihood of Incentivizing Individual Participation

Much of the informal literature surrounding PWFD and their impact on exercise suggests they greatly help incentivize individuals to get enough exercise. While this "commonsense" approach to PWFD has not been supported in academic literature, studies of the effects of pedometers on individual participation suggest that the using PWFD to encourage CMT is **"moderately likely to incentivize individual participation**" (Lystrup et al., 2015 & Jauho et al., 2015 & Sullivan & Lachman, 2016)

Security Risks

This intervention is **high risk** and very likely to worsen security. Unofficial or unsanctioned PWFD use in combat zones has already posed an incredible risk to personal and operational security through the revelation of U.S. military and government presence in the Middle East and North Africa on STRAVA – a social media application for Fitbit that tracks and shares user running and cycling routes. The sanctioned use of PWFD would potentially enable the widespread collection of pattern-of-life data, operational patterns, security routines and other information that could pose a tremendous risk to security at bases or outposts in combat zones.

Option 2: Replace Standard PT with HITT for Deployed Soldiers [HITT]

The Army will replace the standard PT regiment with HITT programming for soldiers deployed to combat zones. Soldiers will deployed to combat zones will receive an information manual with an outline of HITT principles, set workout schedules, and explanations and pictures of how to safely perform necessary exercise moves.

Cost

The costs for this intervention can be accounted for by the printing costs of providing an information manual for soldiers. While HITT workouts can be enhanced through purchased equipment, equipment is not required to complete the workouts and supplying and transporting equipment to forward-deployed locations would be extremely difficult. The Marine Corps HITT program relies predominantly on materials and equipment found around base. Development of the program will not incur additional costs as it will be included in on-going fitness reevaluation processes conducted through the U.S. Army Training and Doctrine Command.

A 150-page training manual will be produced and distributed to every soldier deployed to combat zones. At an industry standard of $0.07 per page copied, each manual will be $10.50 and will cost **$1,068,773** over five years. This is also the total program cost over five years.

Effectiveness – Change in VO_{2max}

Two studies of HITT interventions in "trained" males and athletes found that the introduction of HITT as the exercise method of choice increases VO_{2max} by approximately **7 percentage points** [range of 5.5-9.1 percentage point increase], which would reduce the 8.35 percent decrease to a 1.35 percent decrease. (Esfarjani & Laursen, 2007 & Helgerud et al., 2007).

As a note, there is extensive literature supporting greater increases in VO_{2max} resultant from HIIT that would present a more compelling argument for its use to improve cardiovascular endurance among soldiers deployed to combat zones. However, these studies have focused almost exclusively on improving the fitness and cardiovascular endurance of sedentary and non-athletic individuals. Deriving estimates of increases in VO_{2max} from these studies would be inappropriate in an application to highly-athletic and trained soldiers where "lower improvement in VO_{2max} at higher fitness levels" is expected (Helgerud et al., 2007).

Cost-Effectiveness
Given the estimates above, the cost-effectiveness of maintaining the HITT program for five years is projected to be approximately **$12,975** per percentage point gained in VO_{2max}.

Minutes of Exercise Required Per Week
The proposed HITT intervention is modeled on the USMC HITT program, however the USMC program is designed to be conducted every day for 30 minutes - excluding stretching (Marine Corps, 2018). Given the aforementioned time constraints, this program will be conducted for the suggested 30 minutes, but will be limited to three days of exercise a week, the minimum amount of exercise necessary to realize fitness benefits associated with HITT (Metcalfe, Babraj, Fawkner, & Vollaard, 2012). Soldiers will conduct approximately **90 minutes of aerobic exercise per week**.

Injury Rate
A study of domestically-stationed soldiers adopting a HIIT program similar to the suggested HITT intervention found that the injury rate was five percent (Poston et al., 2016). This intervention is projected to maintain the current injury rate of five percent.

Likelihood of Incentivizing Individual Participation
There have been no formal studies of the impact of HITT (or HIIT) in incentivizing individual participation or adherence to the program of exercise. Anecdotal reporting suggests that HITT interventions are likely to incentivize exercise in individuals already considered somewhat physically fit, a category encompassing nearly every soldier deployed to a combat zone. Further, adherence to HITT programs tends to wane after starting the programs, suggesting maintenance of programs is more difficult than uptake. However, some of these effects are likely to be mitigated if entire units adopt the program. Therefore, the adoption of HITT as the PT method of choice for soldiers deployed to combat zones is **"moderately likely to incentivize individual participation**."

Security Risks
This intervention is **low risk** and unlikely to affect security. Given that the entirety of the HITT intervention will occur on base, there is no additional risk posed to troops.

Option 3: Adopt the "Force Fitness Instructor" Model [FFI]

The Army will adopt the USMC Force Fitness Instructor (FFI) personal training model for platoons deployed to combat zones. FFIs will be responsible for designing and implementing an exercise regimen that will increase overall fitness and increase cardiovascular endurance. Like their Marine counterparts, Army FFIs will be focused on "optimizing performance, increasing durability, and maximizing [combat] readiness" for their units and assist the unit in implementation (Panzino & Bacon, 2016 & USMC, 2018). "Directly supervised" training has been shown to increase training gains compared to unsupervised training and increase personal dedication to exercise (Mazzetti, Kraemer, Volek, Duncan, Ratamess, Gómez, & Fleck, 2000).

The Army will create FFI as an occupational specialty and make FFI slots available to enlisted soldiers [ranked at sergeant or above] and provide training to selected individuals. For the first five years of this program, soldiers will be co-located for six weeks to participate in training classes at the USMC Force Fitness Readiness Center in Quantico, Virginia. After six-weeks of training, the FFI trained soldier will join his or her platoon in the combat zone and begin implementing the training program. Soldiers will still be responsible for other duties around base, but their primary focus will be the physical fitness of soldiers in their platoon.

FFIs will follow guidelines outlined by the APRT. Specific regimens will be created and implemented on a platoon-basis, but will include elements of aerobic exercise and strength training in each session. A standard program "consists of a warm-up, 50 minutes of exercise, and a cooldown" (Heinrich, Spencer, Fehl, & Poston, 2012).

Cost

The costs for this intervention can be accounted for by the personnel costs associated with deploying FFI to combat. These FFI will be drawn from the pool of current soldiers with the rank of Sergeant or above and at least four years of experience. The Army will deploy a FFI for every platoon, or approximately one for every 50 soldiers, in a combat zone. The additional costs mentioned below includes training costs to include the cost of FFI training at Quantico. The Army will not incur an additional cost for this training.

For the 20,184 soldiers deployed in combat zones, 404 FFI will have to be deployed. The *additional* costs associated with deploying these FFI are **$153,367.80** and assumed to be the direct cost of maintaining a soldier in a combat zone [$185,397], excluding the salary these individuals would be receiving regardless of deployment status [$32,029.2 – average basic pay for a Sergeant with 4 years of experience]. This will cost **$312,219,600.35** over five years.

Effectiveness – Change in VO_{2max}

There is no literature identifying the effects of personal training or FFI on increasing VO_{2max} in soldiers or other individuals. The effects of a FFI can be best estimated by identifying the effects of adding a strength training component to a more traditional basic training or CMT routine. In this vein, a study of the effects of the addition of a strength training program to a basic training course for Finnish soldiers found that VO_{2max} was increased by approximately 6 percentage points (Santtila, Keijo, Laura, & Heikki, 2008).

Using this estimate and the assumption that FFI will introduce a combination of aerobic and strength training in sessions with soldiers, the adoption of the FFI model is expected to increase VO_{2max} in U.S. soldiers deployed to combat zones by **6 percentage points**, which would reduce the 8.35 decrease in VO_{2max} to a 2.35 percent decrease.

Cost-Effectiveness

Given the estimates above, the cost-effectiveness of maintaining the FFI program for five years is projected to be approximately **$10,318,585.58** per percentage point gained in VO_{2max}.

Minutes of Exercise Required Per Week

Based on the USMC FFI program and other examples of personal training programs, Army FFI are expected to instruct soldiers in aerobic and strength training – adhering to APRT guidelines – for 60 minute sessions, four days a week. Soldiers will be conducting approximately **240 minutes of aerobic exercise per week**.

Injury Rate

A study of soldiers strictly adhering to APRT guidelines – as expected under the FFI model - found that the injury rate was 7 percent (Poston et al., 2016). However, personal training has been found to decrease injuries incidence by enabling the identification of incorrect form or overuse before they cause injuries. Therefore, this intervention is projected to only increase the current injury rate from five percent to **6 percent**.

Likelihood of Incentivizing Individual Participation

There have been no formal studies of the impact of FFI or personal trainers on incentivizing individual participation. However, anecdotal reporting suggests that having a personal trainer to report to and who can keep track of attendance will increase individual participation. Therefore, the adoption of the FFI model is **"very likely to incentivize individual participation**."

Security Risks

This intervention is **low risk** and unlikely to affect security. Given that the entirety of FFI instruction will occur on base, there is no additional risk posed to troops.

VII. Outcomes Matrix

The Status Quo, Intervention Options, Evaluative Criteria, and Projected Outcomes

		Status Quo	Option 1: CMT + PWFD	Option 2: HITT	Option 3: FFI
Evaluative Criteria	**Cost**	$0	$7,185,306.76	$1,068,773	$312,219,600.35
	Effectiveness- (Change in VO_{2max})	-8.35%	+2.00 percentage points	+7.00 percentage points	+6.00 percentage points
	Cost-Effectiveness ($ per percentage point gain in VO_{2max})	n/a	$712,404.37	$30,276.00	$10,318,585.58
	Minutes of Exercise Per Week	69	117	90	240
	Injury Rate	5%	15%	5%	6%
	Likelihood of Incentivizing Individual Participation	Unlikely	Moderately Likely	Moderately Likely	Very Likely
	Security Risks	Low Risk	High Risk	Low Risk	Low Risk

Note: Effectiveness estimates are not presented as Net Present Value, instead as the estimated percentage point change in VO_{2max} in one-year. This was done so that the reader could more easily see how this percentage point gain would affect the status-quo percent loss in VO2max. (i.e. -8.35% +4.00 percentage points = -6.35%; meaning that instead of soldier VO2max decreasing by 8.35% it is decreasing by 4.35%)

VIII. Recommendation, Implementation, & Further Considerations

A. Recommendation

Based on the projected outcomes of the proposed interventions, it is recommended that the Army chose Option 2 and implement HITT as the PT method of choice for soldiers deployed to combat zones, replacing standard PT programs.

Rationale

The implementation of HITT is most cost-effective outcome, but also requires the least amount of additional time spent exercising, doesn't increase the injury rate, and poses no additional security risks to military operations or personnel.

Considerations

As described, the HITT program provides the greatest benefit to improving VO_{2max} at the lowest cost and with the least negative externalities, in comparison to other options. This intervention capitalizes on already existent trends in military [and civilian] fitness and will be minimally disruptive to Army operations in combat zones, requiring the least amount of time needed to supplement existing fitness routines. While this is a 30 percent increase in time, this intervention is the most time-effective when compared to Options 1 and 3. Importantly, HITT exercise does not increase the injury rate among soldiers. The average total cost to the military of a musculoskeletal injury is $3,021 suggesting that the prevention of additional injuries could potentially save the Army a significant amount of money when compared to Options 1 and 3 (*Cost of Injuries to the Military*, 2007).

While not a criterion on which interventions were evaluated, HITT does not require the availability of resistance or cardio equipment. This will allow the program to be continued, when possible, at off-base locations and ensure consistency despite operational variability. Most FOB have cardiovascular and resistance equipment available for use, but anecdotal evidence suggests COP and PB have extremely limited resistance equipment available and no cardiovascular equipment available.

B. Implementation

Developing and adopting HITT in place of existent PT programs for soldiers deployed to combat zones will be a relatively straightforward process, allowing the intervention to be implemented quickly. Army physicians and physical trainers will examine the USMC HITT program and make adjustments necessary to ensure the program meets Army standards and physical fitness goals. After these adjustments have been made, the final instruction manual will be compiled, printed, and shipped to soldiers in combat zones. After the manual has been received, Army soldiers can begin incorporating HITT workouts into their existing PT plans, eventually replacing all of the old plans.

When considering implementation of this intervention – or any other – it is important to note that the Army must consider the environment in which soldiers operate while deployed to combat zones. The majority of currently designated combat zones are located in extremely hot climates, some of which are at altitude. As mentioned in PRT guidelines, soldiers must be given the opportunity to acclimatize to their environments upon arrival and PT must be conducted in a safe manner with consideration given to health consequences. HITT workouts are especially strenuous and care should be given to ensure soldiers do not overwork themselves.

C. Further Considerations

While HITT workouts will likely mitigate the majority of the decrease in VO_{2max} experienced by soldiers deployed to combat zones, the Army and other research should still seek to investigate other potential causes for decreased cardiovascular health in soldiers deployed to combat zones. Existing literature suggests that psychological stressors (including lack of sleep) likely plays a contributing role in the increased incidence of CVD and other negative cardiovascular health markers (Costa & Kahn, 2006 & Martins & Lopes, 2013 & Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009). Additionally, concerns about Army nutrition – despite the involvement of nutritionists in the development of Army dietary plans – have been noted as an additional source of diminished cardiovascular health (Vanhees, Geladas, Hansen, Kouidi, Niebauer, Reiner, & Börjesson, 2012). However, even if these potential factors are addressed, the Army must still seek to improve engagement in aerobic exercise by soldiers deployed to combat zones.

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Appendix A:
Cost-Effectiveness Analysis Background

This appendix – in addition to Appendix B and the attached Excel spreadsheet – should be used to view the cost-effectiveness analysis used to calculate outcomes as identified in the "Outcomes Matrix" on page 40.

Baseline

The baseline assumptions to which intervention outcomes were compared are detailed in the "Status Quo" section on page 29.

Program Length and Discount Rate

This analysis was conducted assuming programs would be in place for five years and using the Office of Management and Budget (OMB) suggested discount rate of 7 percent.

Effectiveness

Effectiveness is measured as the percentage point change in VO_{2max}. This measure was selected as the literature discussing the benefits of various exercise options on VO_{2max} are detailed almost exclusively in percentage point changes. The net present value (NPV) of these percentage point changes overtime are used as the figure for the cost-effectiveness analysis. However, the "Outcomes Matrix" depicts effectiveness as simply the projected percentage point change in the first year, rather than the NPV of the projected percentage point change over five years. This was done to allow the reader to easily identify the impact of an intervention on the 8.35 percent decrease in VO_{2max} currently experienced by soldiers deployed to combat zones. For example, if an intervention increases VO_{2max} by 2 percentage points, the -8.35% change is decreased to a -6.35% change in VO_{2max}..

Costs

Costs are all borne by the Department of the Army and were measured in United States Dollars (USD). These costs include material and personnel expenditures required to develop and implement proposed interventions.

Material costs include the cost of printing any documents required to facilitate an intervention and the purchase of any necessary equipment. Material costs have been derived from industry standards and market prices as appropriate.

Personnel costs will be measured by salary, support, and maintenance expenditures necessary to execute a program. Existent personnel deployed to combat zones are not considered in this cost-effectiveness analysis. Military personnel salaries have been taken from the 2018 Military Basic Pay Scale. Time spent conducting PT while working will not be calculated as lost productivity among soldiers given that PT is a job requirement.

Training time during leisure hours will also not be calculated as lost productivity.

Assumptions

As noted [where appropriate] in Appendix B, many of the projected outcome estimates and other assumption choices were arrived by combining various research articles and making "best guesses" when literature did not address the specific assumption of interest, or aspects thereof.

Projected estimates of percentage point change in VO_{2max} were calculated using the numerical averages reported in literature, so it is highly likely most service members will experience a greater or lesser change in VO_{2max}. However, this won't change the outcomes as the reported assumption estimates are the numerical average of these projected changes.

While not a quantitative assumption, it is important to note that the number of required materials or personnel was rounded up in all instances rather than down to ensure that all personnel received requisite materials.

All quantitative assumptions are included in Appendix B.

Appendix B:
Cost-Effectiveness Analysis Quantitative Assumptions

General Assumptions

Unless otherwise noted, assumed rates refer to soldiers deployed to combat zones.

Assumption	Choice	Justification/Source
Discount Rate	7%	Best practice from OMB[1]
Printing Cost Per Page	$0.07	Industry Standard Price for a Black & White Copy[2]
Total Direct Personnel Maintenance Expenditures	$3,742,059,000	FY 2019 Defense Budget Request (individual requests below)
Personnel Expenditures	*$3,161,444,000*	*Military Personnel OCO FY19 Request*[3]
Personnel Related Operation and Maintenance	*$580,615,000*	*Operations and Maintenance OCO FY19 Request*[4]
Number of Soldiers	20,184	Projected Number of Deployed Soldiers Receiving Imminent Danger Pay, FY19 [5]
Direct Cost Of Maintaining a Soldier	$185, 397	Major Combat Zone Expenditures divided by No. of Soldiers

FY – Fiscal Year; OCO – Overseas Contingency Operations

Note: Publicized costs on the price per soldier in combat zones are typically higher than those shown here. However, most of these figures report the total expenditures in a country divided by the number of soldiers in country. These figures include fixed costs not variable with the individual soldier including construction, ammunition, etc. The Obama Administration reportedly used the figure "$1 million to send one soldier to war for a year" in Afghanistan in briefings with Congress on the matter. DoD disputed this number, estimating it was likely closer to $500,000 however a former CFO at DOD noted that the "$1 million price tag includes getting the soldier to Afghanistan, getting his equipment to Afghanistan, and moving the soldier around once in the country."[6][7]

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[1] Office of Management and Budget. (2003). *Regulatory Analysis* (Circular No. A-4). Office of Management and Budget.

[2] Talbot, et al. (2013). Cost Effectiveness of Two Army Physical Fitness Programs.

[3] Department of Defense. (2018b). *Military Personnel, Army Justification Book* (Fiscal Year (FY) 2019 Budget Estimates).

[4] Department of the Army. (2018). *Overseas Contingency Operations (OCO) Request* (Operation and Maintenance, Army No. Volume III).

[5] Department of Defense. (2018b). *Ibid.*

[6] Kelly, M. L. (2009, October 29). Calculating The Cost Of The War In Afghanistan. *NPR All Things Considered*.

[7] Shaughnessy, L. (2012, February 28). One soldier, one year: $850,000 and rising. *CNN*.

Status Quo

Unless otherwise noted, assumed rates refer to soldiers deployed to combat zones.

Assumption	Choice	Justification/Source
Current Minutes/Week of Aerobic Exercise (PT) During Deployment to Combat Zones	69 minutes	2.25 days [*Weighted average days of aerobic exercise in soldiers deployed to Afghanistan and Iraq]* x 30.5 minutes [*Weighted average minutes per session in soldiers deployed to Afghanistan and Iraq*][8][9]
Pre-Deployment VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	*49.7*	*Average of pre-deployment VO_{2max} in soldiers deployed to Afghanistan (50.8 $mL \cdot kg^{-1} \cdot min^{-1}$) and Iraq (48.6 $mL \cdot kg^{-1} \cdot min^{-1}$)*[10][11]
Post-Deployment VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	*45.55*	*Average of post-deployment VO_{2max} in soldiers deployed to Afghanistan (48.5 $mL \cdot kg^{-1} \cdot min^{-1}$) and Iraq (42.6 $mL \cdot kg^{-1} \cdot min^{-1}$)*[12][13]
Percent Change in VO_{2max} during deployment*	-8.35%	-4.15 ($mL \cdot kg^{-1} \cdot min^{-1}$) ÷ 49.7 ($mL \cdot kg^{-1} \cdot min^{-1}$)

VO_{2max} – maximum volume of oxygen; NBRI – non-battle-related injury; PT – physical training

Note: Options for intervention presented in the report seek to help negate the given negative percent change in VO_{2max} resultant from deployment: interventions that increase VO_{2max} in individuals will be applied to this percent change, rather that the initial pre-deployment level of VO_{2max}. This report operates under the assumption that soldiers are going to experience a -8.35 percent change in VO_{2max} during deployment. Ideally, interventions would prevent this change and soldiers would maintain pre-deployment VO_{2max} levels. However, there is no research that demonstrates the effectiveness of interventions in maintaining VO_{2max} in physically fit individuals, making any assumptions of fully preventing the change from pre- to post-deployment speculative.

[8] Sharp, et al. (2008). Physical Fitness and Body Composition after a 9-Month Deployment to Afghanistan.
[9] Lester, et al. (2010). Effect of a 13-Month Deployment to Iraq on Physical Fitness and Body Composition
[10] Sharp, et al. (2008). Physical Fitness and Body Composition after a 9-Month Deployment to Afghanistan.
[11] Lester, et al. (2010). Effect of a 13-Month Deployment to Iraq on Physical Fitness and Body Composition
[12] Sharp, et al. (2008). Physical Fitness and Body Composition after a 9-Month Deployment to Afghanistan.
[13] Lester, et al. (2010). Effect of a 13-Month Deployment to Iraq on Physical Fitness and Body Composition

Option 1: CMT + PWFD

Assumption	Choice	Justification/Source
iPod Touch	$199.00	Market Price[14]
Percent of Soldiers Who Do Not Possess an iPod Touch or SmartPhone	5%	95% of all American adults have these devices based on consumer trends[15]
FitBit Flex2	$59.99	Market Price of Device[16]
Percent of Soldiers Who Already Possess a PWFD	10%	Market data suggests 1 in 10 American adults owns a fitness tracker[17]
Number of Pages in Training Manual	95	Manuals given for a similar program were 95 pages long[18]
Projected Change in VO_{2max}	+2%	Average Increase in VO_{2max} of Two CMT Interventions In "Moderately-Trained Males"[19]

Note: There is extensive literature supporting greater increases in VO_{2max} resultant from CMT that would present a more compelling argument for its use to improve cardiovascular endurance among soldiers deployed to combat zones. However, these studies have focused almost exclusively on improving the fitness and cardiovascular endurance of sedentary and non-athletic individuals. Deriving estimates of increases in VO_{2max} from these studies would be inappropriate in an application to highly-athletic and trained soldiers where "lower improvement in VO_{2max} at higher fitness levels" is expected. [20]

[14] Apple. (2018). iPod Touch.
[15] Smith, A. (2017). *Record shares of Americans now own smartphones, have home broadband*. Pew Research Center.
[16] Fitbit. (2018). *fitbit flex 2: Fit for every you.*
[17] Riley, D. (2015). *The Demographic Divide: Fitness Trackers and Smartwatches Attracting Very Different Segments of the Market, According to The NPD Group.*
[18] Talbot, et al. (2013). Cost Effectiveness of Two Army Physical Fitness Programs.
[19] Helgerud, et al. (2007) Aerobic High-Intensity Intervals Improve VO2max More Than Moderate Training.
[20] Ibid.

Option 2: HITT

Assumption	Choice	Justification/Source
Number of Pages in Training Manual	150	The USMC HITT Methodology manual is 32 pages in length[21] and other HIIT workout program manuals are approximately 100 pages in length.[22]
Projected Change in VO_{2max}	+7%	Average increase in VO_{2max} in studies of the effects of HIIT on "trained" male individuals and athletes (Range from studies: 5.5-9.1% increase)[23][24]

Note: There is extensive literature supporting greater increases in VO_{2max} resultant from HIIT that would present a more compelling argument for its use to improve cardiovascular endurance among soldiers deployed to combat zones. However, these studies have focused almost exclusively on improving the fitness and cardiovascular endurance of sedentary and non-athletic individuals. Deriving estimates of increases in VO_{2max} from these studies would be inappropriate in an application to highly-athletic and trained soldiers where "lower improvement in VO_{2max} at higher fitness levels" is expected. [25]

[21] United States Marine Corps. (n.d.). *HITT High Intensity Tactical Training Methodology*.
[22] Itsines, K. (2018). Bikini Body Guide Workouts - Exercise & Training Plan.
[23] Helgerud, et al. (2007). Ibid.
[24] Esfarjani, F., & Laursen, P. B. (2007). Manipulating high-intensity interval training: Effects on , the lactate threshold and 3000m running performance in moderately trained males.
[25] Helgerud, et al. (2007). Ibid.

Option 3: FFI

Assumption	Choice	Justification/Source
FFI	$32,029.20	Average salary of a sergeant with four years of experience[26]
Projected Change in VO_{2max}	+6%	Estimate based on a study of the effects of the addition of a strength training program to a basic training course for Finnish soldiers[27]*

**Note: No literature was identified that studied the effect of personal training (the broader category for Force Fitness Instructors) on changes in VO_{2max} or other fitness markers among physically-fit individuals. This report assumes FFI will introduce a combination of aerobic and resistance (strength) training in sessions with soldiers, for 60 minutes, four days a week.*

[26] U.S. Army. (n.d.). Benefits.

[27] Santtila, M., Keijo, H., Laura, K., & Heikki, K. (2008). Changes in Cardiovascular Performance during an 8-Week Military Basic Training Period Combined with Added Endurance or Strength Training.