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Baseline Soldier Physical Readiness Requirements Study

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FOREWORD

This Technical Report is the final report documenting research directed by HQDA EXORD 041-13, the Baseline Soldier Physical Readiness Requirements Study published in OCT 2013. There were three directives for the Baseline Soldier Physical Readiness Requirements Study (BSPRRS). The first directive was to determine the baseline physical readiness requirements of the physically demanding, commonly occurring and critical Warrior Tasks and Battle Drills and Common Soldier Tasks (WTBD/CST). The second directive was to determine if the current 3-event Army Physical Fitness Test (APFT) adequately assessed the baseline physical readiness required to accomplish physically demanding WTBD/CSTs. The third directive was to determine if there were other physical fitness test events that better predicted Soldier performance on physically demanding WTBD/CSTs. Guidance from Army senior leadership was not to delimit fitness test events based on administrative time or equipment costs. The final outcome of the BSPRRS study was the development of a physical fitness test battery to assess WTBD/CST performance. This physical fitness screening test, now called the Army Physical Fitness Test (ACFT), provides acceptable predictive validity ($R^2 > 0.835$, $p = 0.000$) to identify Soldiers capable of executing high-demand, commonly occurring and critical WTBD/CSTs.

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List of Acronyms

ACH	Army Combat Helmet
AIT	Advanced Individual Training
AAR	After Action Report
ACU	Army Combat Uniform
AI	Associate Investigator
APFT	Army Physical Fitness Test
ATP	Adenosine Triphosphate
BCT	Brigade Combat Team
BSPRRS	Baseline Soldier Physical Readiness Requirements Study
CAB	Combat Aviation Brigade
CST	Common Soldier Tasks
EMT	Emergency Medical Team
EXORD	Executive Order
FAASV	Field Artillery Ammunition Supply Vehicle
FM 7-22	Field Manual 7-22: Army Physical Readiness Training
FORSCOM	U.S. Army Forces Command
GPP	General Preparation Phase
HQDA	Headquarters Department of Army
HR	Heart Rate
IOTV	Improved Outer Tactical Vest
MEPS	Military Entrance Processing Station
MSK-I	Musculoskeletal Injuries
MOS	Military Occupational Specialty
MTF	Medical Treatment Facility
NCOIC	Non-commissioned Officer-in-Charge
NTE	Not to Exceed
OCP	Occupational Camouflage Pattern
OPAT	Occupational Physical Assessment Test
OPORD	Operation Order
OSUT	One Station Unit Training
OUAT	Over-Under-Around-Through
PI	Principal Investigator
PRT	Physical Readiness Training
PT	Physical Training
PWC	Physical Work Capacity
RPE	Rate of Perceived Exertion
SME	Subject Matter Expert
TRADOC	Training and Doctrine Command
USACIMT	U.S. Army Center for Initial Military Training
USAPHC	U.S. Army Public Health Center
USARIEM	U.S. Army Research Institute of Environmental Medicine
VO2	Volume of Oxygen
WTBD	Warrior Tasks and Battle Drills

BACKGROUND

The U.S. Army has utilized a variety of physical fitness assessments over the last 100 years. Army physical fitness tests were generally comprised of five to seven events, and have included physical fitness events (e.g., pull-ups, 2-mile run) and functional fitness events (e.g., horizontal ladders, dodge and jump, pig-a-back carry). In the mid 1070's, after four decades of growth and change in the Army's assessment of physical fitness, the Army began preparation to terminate the Women's Army Corp (WAC) and integrate women into the regular Army. Beginning in 1975, men and women Soldiers took a semiannual Advanced Physical Fitness Test based upon mission essential task requirements. The men's events were: inverted crawl, run/dodge/jump, horizontal ladder, sit-ups, and 2-mile run (FM 21-20 1973). The women's events were: 80m shuttle run, push-ups, sit-ups, run/dodge/jump, 1-mile run (FM 35-20 1975). With the impending integration of women into the regular Army, a 1976 GAO report made two recommendations; military services were encouraged to develop fitness assessments that: (1) had genderless performance standards to enhance performance and (2) were easy to administer and required minimal equipment (GAO 1976). In 1980, a three-event Army Physical Readiness Test (APRT) was published as the first gender-integrated Army physical fitness test. (FM 21-20 1980). The three APRT events were push-ups, sit-ups, and 2-mile run, and performance standards were adjusted by gender and age (DA 2011a, DA 2010, McCrary 2006). In 1985, the test name was changed to the Army Physical Fitness Test (APFT). Although the stated purpose of the APFT was to "evaluate the Soldier's physical readiness to perform assigned tasks," the APFT was never validated against any criterion-referenced standard; the basis for the scoring standards is unclear (GAO 1998).

Given the lack of scientific evidence to validate APFT test events or scoring standards, particularly as they relate to Soldiers' physical capacity to perform WTBD/CSTs, over the last decade the U.S. Army has evaluated numerous changes to the APFT. A 2002 seven-event Army Physical Readiness Test (APRT) was proposed though not implemented (USACHPPM 2002). In 2012, a five-event APRT was proposed that included a 60-yard shuttle run, one-minute rower, standing long jump, one-minute push-up with no rest allowed, and a 1.5-mile run for time (DA 2011b). The use of the proposed 2012 APRT, as a replacement of the APFT, was considered premature by the Chief of Staff of the Army (CSA), who directed the execution of a comprehensive scientific study to identify test events that would "more accurately predict Soldier performance of Warrior Tasks and Battle Drills," and also provide a determination for the "threshold for success… for all soldiers, independent of age or gender." (HQDA 2012a, HQDA 2012b; HQDA 2013). This directive (HQDA EXORD 041-13) is the initiative behind this Baseline Soldier Physical Readiness Requirements Study (BSPRRS).

Physical/Health- and Motor/Skill-Related Components of Physical Performance

Historically, physical performance has been dichotomized into two domains: physical/health-related fitness and motor/skill-related fitness. Physical/health-related fitness is generally considered to be the quantitative aspect of human performance, while motor/skill-related fitness is the qualitative aspect of human performance. As part of the BSPRRS study, USAPHC conducted a systematic review and meta-analyses of previously published military and non-military data on correlations between military tasks and physical fitness tests (ICSPP 2014). Although the review and analyses were broad reaching, a portion addressed the assessment of physical/health-related fitness and motor/skill-related fitness (see Table 1).

Physical/Health-Related Components of Physical Performance

Cardiovascular endurance

Cardiovascular (aerobic) endurance (CVE) is defined as the ability to utilize oxygen to conduct sustainable (submaximal) physical work over long periods of time. CVE is strongly associated with the performance of common military tasks (USAPHC 2014b). Of the cardiovascular tests evaluated (i.e., timed runs, runs for maximum distance in set time, and VO_{2max} measurements), VO_{2max} measures provided the strongest association to task performance. This finding is not surprising since the "gold standard" for determining the *validity* of CVE tests is based on a comparison to VO_{2max}. The high rate at which military personnel must utilize energy, especially in combat environments, has been demonstrated through specific measurements of energy expenditure (Tharion 2003, Hoyt 2006). Physical overexertion in conjunction with an energy deficit was also proposed as the underlying cause of performance decrement of Soldiers after 72 hours of operational stress (Nindl 2002). Therefore, for continuous operations that involve multiple and repeated tasks over time, cardiovascular endurance appears to be a predominant fitness component.

Field expedient tests, such as timed-run tests of 1.5 to three miles, are generally found to be valid measures of CVE. The data do not support discernable differences in the validity for runs of greater than 1.5 miles. The reliability of these timed-run tests (consistent results), has also been reported as very good. Reliability coefficients for run tests of distances up to two miles have been reported as >0.82 - 0.98 (USACHPPM 2004). In addition, run tests are field expedient – they require no equipment other than a stopwatch, and can be done in large groups.

Muscular Strength

Muscular strength is defined as the ability to produce high intensity movements requiring maximal/near maximal force for singular or limited repetitions (generally < six repetitions). While muscle strength has been shown to have an inconsistent relationship with musculoskeletal resilience (IOM 2007), a recent study of female Marines demonstrated that upper body strength was the largest predictor of performance on common military tasks (Kelly and Jameson, 2016). In an extensive review of the muscular strength and athletic performance literature Suchomel, et al. (2016) concluded that greater muscular strength was associated with enhanced force development, general sport skill performance, specific sport skill performance, and decreased injury rates. Their final key point was greater muscular strength is vastly influential in improving an individual's overall performance (Suchomel, et al., 2016)

Assessments of muscular strength often target the upper body and lower body. Maximum effort one repetition tests (1RM) are generally accepted as the gold standard in assessing muscular strength. However, in an attempt to avoid injury in attempting maximum weight lifts, researchers and coaches often use multiple repetition-lifts as a proxy test of 1RM. The U.S. Army 75th Ranger Regiment utilizes a three repetition maximum deadlift test as part of their RAW assessments (Ranger Athlete Warrior), and the U.S. Air Force developed an Air Liaison Officers / Tactical Air Control Party Operators physical fitness test with a five repetition maximum deadlift test.

The most common upper-body strength exercises include the bench press, military press, biceps curls, and "lat" pull-downs. The pull-up is also often categorized as a "strength" measure since the force demand/repetition is ~ 65-75% of body mass, and most individuals execute less than six repetitions. These exercises have face validity, and generally correlate with task performance in trained populations. The most common lower-body strength exercises are the deadlift, back squat, and various kettlebell/dumbbell squats (sumo squat) and weighted lunges. There are two general concerns with assessing muscular strength: (1) equipment costs, and (2) precision requirements associated with "lifting technique." Without proper instruction and training, muscular strength testing can result in an increase in musculoskeletal injuries (MSK-I).

Muscular Endurance

Muscular endurance is defined as the ability to produce low intensity movements requiring sub-maximal force for relatively long periods of time/repetitions. Studies have found that increased upper body muscular endurance results in improved musculoskeletal resilience (IOM 2007). Muscle endurance is typically measured for three regions of the body: upper-body, lower-body and core. While upper- and lower-body muscular endurance are moderately-to-strongly associated with military task performance, core endurance has shown to be less relevant (USAPHC 2014b). Lower-body muscular endurance assessments, like kettlebell / grapefruit squats, are seldom included in Army PFTs due to the implied association with distance running (all Army PFTs since 1970 included a distance run). In most cases, muscular endurance exercises used by the U.S. Army are "body weight" assessments that measure muscular endurance as a function of repetitions to volitional fatigue. Using body weight as an absolute workload standard creates obvious problems when the exercise is used to predict performance on a criterion task, i.e., lifting a 155mm round (103 pounds).

The most frequently studied test of muscular endurance is the push-up. The push-up test is field expedient, requiring no equipment and limited instruction, and has historical relevance in the Army. The pull-up is another field-expedient test that has been repeatedly used by the Army to assess upper-body endurance. A benefit of the pull-up test is it requires a greater percentage of force per repetition than the push-up (between 60-70%), requiring fewer repetitions (less time to administer), and yielding higher objectivity (inter-rater reliability). However, due to a relative lack of strength, for certain individuals the pull-up test becomes a test of muscular strength (six or fewer repetitions), rather than muscular endurance. Other measures of muscular endurance include: kettlebell (goblet) squat, dips, burpees and sit-ups. Additional measures used by the U.S. Army to assess / train core endurance are the abdominal rower and modified sit-up/crunch. Similar to the increased absolute workload required by the pull-up, the Army has also used field-expedient exercises such as the heel clap, heel hook, ankles to the bar, and leg tuck to assess higher intensity core endurance / strength, since these exercises require a greater force generation per repetition, which results in fewer repetitions.

Motor/Skill-Related Components of Physical Performance

The most common components of motor/skill-related fitness are: agility, coordination, speed, power, and balance (Casperson 1985, USAPHC 2014b). Over the past 20 years, as the science of physical training and assessment has matured, the term motor/skill-related fitness has become relatively obsolete, particularly related to the components of speed and power. Speed has emerged as a function of muscular strength and anaerobic power/endurance. Although speed can

be interpreted as the ability to do physical tasks "quickly" (e.g., fill sandbags), the most common performance metric is the ability to move the body rapidly over short distances, e.g., the 40m - 400m sprints. Performance of this skill is degraded by external loads. However, speed is intuitively valuable to the performance of military tasks, particularly in combat. A previous review of sprint tests indicated they have good reliability (reliability coefficients range from 0.87 to 0.98; USACHPPM 2004, Burnstein 2011), and require minimal equipment and logistics to conduct.

Explosive power has emerged as an integral measure of athletic power, and is defined as a function of force/time, where force is directly related to muscular strength. The assessment of power often manifests as the ability to throw an object/move the body in one "explosive" movement. Field-expedient measures of upper body power often include puts and throws, e.g., the shot put, discus, basketball throw, medicine ball throw. These measures require minimal equipment and are highly reliable ($r = .866$, standing long jump) and valid (standing long jump and leg extension test, $r = .836$) due to the nature of maximal effort tests (Fernandez-Santos 2015). Field-expedient tests of lower body power often include "jump" tests (e.g., vertical jump, standing long jump, counter jump, and triple or single hops). Jump tests generally have good reliability (reliability coefficients ranged from 0.76 – 0.96, Markovic 2004) and strongly correlate to select military performance tasks.

For the past 100 years, the U.S. Army has used a variety of field expedient test events that combined multiple components of motor/skill-related fitness. These tests were considered more functional in nature (e.g., horizontal ladder) and incorporated aspects of speed, power, agility and coordination into high-intensity, short-duration tests (e.g., run-dodge-jump). Running agility tests, like the 300yd shuttle run or the run-dodge-jump tests, were the most common short duration shuttle tests (FM 21-20 1973). Other sprint-agility field test include the AAHPERD shuttle test, Illinois agility test, and the 5-10-5 Pro Agility Test (East 2013). The most common longer duration shuttle run is the 300yd shuttle run. While assessing individual Soldier agility and coordination, these tests also provide an assessment of higher intensity anaerobic endurance, a critical component in combat tasks.

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DISCLAIMERS

The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Army or the Department of Defense. The investigators have adhered to the policies for protection of human subjects as prescribed in Army Regulation 70-25, and the research was conducted in adherence with the provisions of 32 CFR Part 219.

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EXECUTIVE SUMMARY

The Baseline Soldier Physical Readiness Requirements Study was conducted to determine the physical requirements for Soldiers in a combat environment. The study used physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills (WTBD) and Common Soldier Tasks (CST) as a proxy for combat tasks required of all Soldiers. There were three objectives: (1) determine the baseline physical requirements of WTBD/CST; (2) determine combat task performance variability explained by the Army Physical Fitness Test (APFT); and (3) determine if other common physical fitness test events were more predictive of combat task performance.

The Baseline Soldier Physical Readiness Requirements Study was conducted in three phases. In Phase I, researchers conducted a systematic literature review and Soldier interviews, focus groups, and surveys to identify physical performance demands and thresholds across a range of representative Soldier "types." They also deconstructed Army Warrior Tasks and Battle Drills and Common Soldier Tasks to identify tasks that were physically demanding, commonly occurring and critical. In the final part of Phase I, male (243) and female (47) Soldiers (FT Carson, CO) participated in the development of the WTBD simulation test (WTBD-ST). In Phase II, male (278) and female (46) Soldiers (FT Riley, KS) performed the WTBD-ST, the Army Physical Fitness Test (APFT), and 23 common physical fitness test events to determine the baseline physical constructs of high-demand WTBD performance, and to identify a battery of common exercises that predict WTBD-ST performance. To estimate the predictive power of each discrete test event, WTBD-ST performance was regressed against the 23 physical fitness test events using multiple linear regression. In Phase III, male (136) and female (16) Soldiers (FT Benning, GA) performed the WTBD-ST test and the eight (8) physical fitness test events, identified in Phase II as most predictive of high-demand WTBD performance, sequentially with no programmed rest.

Phase II data identified five basic constructs of high-demand WTBD performance: (1) move quickly over, under, around, and through obstacles; (2) lift, carry, and drag heavy loads; (3) generate and apply force; (4) execute submaximal work for long periods; and (5) move for long distances over uneven terrain under heavy loads. Phase II data analysis (FT Riley), revealed that the three-event Army Physical Fitness Test (APFT) was a moderately poor predictor of WTBD-ST performance ($R^2 = 0.432$; $p = 0.000$). The initial step-wise regression model, where average WTBD-ST performance (with fighting load and following pre-fatigue), was regressed on the 23 predictor variables, yielded a high multiple regression coefficient for eight (8) variables ($R^2 = 0.737$[1]; $p = 0.000$): sled drag, power throw, two-mile run, deadlift, sled push, push-up, kettlebell squat, and power throw. While predictive validity was crucial, it was equally as important to the Army to produce a test that assessed all components of fitness. A multi-component physical assessment was essential to transform physical readiness training and reduce musculoskeletal injuries. After considering these qualitative factors, a modified eight (8) event model was developed and analyzed. When modeling the sled drag, two-mile run, deadlift, sled push, push-ups, power throw, leg tuck, and 300yd shuttle run, the analysis generated an $R^2 = 0.733$; $p = 0.000$).

In the Phase III data analysis 136 (male) and 16 (female) Soldiers from FT Benning, GA performed the modified eight (8) physical fitness test events sequentially as a test battery; the

[1] The industry standard for human performance prediction is generally considered to be $R^2 = .70$.

WTBD-ST was also administered on a different day. Four primary predictor variables were identified ($R^2 = 0.832$; p= 0.001): sled drag, power throw, 2-mile run, and deadlift, while four secondary measures accounted for additional variability: leg tuck, sled push, 300yd shuttle run and push-ups ($R^2 = 0.835$, p= 0.000).

Soldiers must be prepared to execute physically demanding tasks across all five basic constructs of combat task performance. In order to ensure successful performance, the Army combat fitness test must measure all components of fitness to include: muscular strength and endurance, aerobic and anaerobic endurance, anaerobic power (speed), and skill-related fitness – flexibility, agility, coordination, and balance. The comprehensive physiological and anatomical balance of the test battery will change the culture of fitness in the Army, focus physical readiness training to enhance combat lethality, and mitigate musculoskeletal injuries.

INTRODUCTION

In December 2012, the U.S. Army Center for Initial Military Training/TRADOC (USACIMT) was tasked (HQDA EXORD 041-13) to determine the baseline physical readiness requirements of the physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills (WTBD) and Common Soldier Tasks (CST). HQDA EXORD 041-13 outlined three research questions for the Baseline Soldier Physical Readiness Requirements Study (BSPRRS): (1) what are the baseline physical readiness requirements of the physically demanding, commonly occurring and critical Warrior Tasks and Battle Drills and Common Soldier Tasks (WTBD/CST); (2) does the current 3-event Army Physical Fitness Test (APFT) adequately assess the baseline physical readiness requirements necessary to execute high physical demand WTBD/CSTs; and (3) if the 3-event APFT was found to be insufficient to assess the baseline physical requirements, what physical fitness test events better predicted a Soldier's ability to execute high physical demand WTBD/CSTs?

The study proceeded in three phases. In Phase I, researchers, led by the USAPHC, conducted a systematic literature review, in-person Soldier focus-groups, and online surveys to identify the physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills and Common Soldier Tasks. Researchers started the review with a comprehensive list of 113 WTBD/CSTs. Based upon feedback from Soldiers and analysis by subject matter experts (SME), the WTBD/CSTs list was reduced to 11 highly demanding, commonly occurring, and critical tasks. Next, the research team (composed of SMEs and Soldiers) deconstructed the 11 WTBD/CSTs into their functional components (e.g., move, carry, lift, drag, jump, etc.). Researchers then identified the physical characteristics associated with each functional component (e.g., drag = muscular strength and power, move = anaerobic and aerobic endurance, etc.). Lastly, researchers overlapped WTBD/CSTs functional requirements and physical characteristics to identify redundancies. In perhaps the best example of the distillation process, five WTBDs contained some aspect of moving quickly over uneven/urban terrain. For example, individual dismounted movement is a component of:

071-COM-0501 Move as a member of a Team
071-COM-0541 Perform Exterior Movement Techniques during an Urban Operation
071-COM-0502 Move under Direct Fire
071-COM-0510 React to Indirect Fire dismounted

071-COM-0503 Move over, Through, or Around Obstacles (Except Minefields)

These five WTBD/CSTs had similar or overlapping physical characteristics (e.g., agility, anaerobic endurance/power (speed), coordination, muscular endurance, etc.). To eliminate the physical redundancies, these five WTBD/CSTs were merged into a single "movement" task. After analyzing all 11 WTBD/CSTs, the research team established five common core tasks: move over long distances under heavy loads, build a hasty fighting position, move over-under-around-through obstacles on uneven-urban terrain, employ progressive levels of force (close quarters combat), and extract and transport a casualty.

In the second part of Phase I, researchers developed a WTBD simulation test (WTBD-ST) that reflected the physical demands of the five WTBD/CST core tasks. A subgroup of the research team met at FT Eustis in June 2013 to develop an assessment vignette (similar to a combat obstacle course) for each of the five task constructs. The first four WTBD/CST vignettes were linked serially to form a ~200m course, with a linear distance of approximately 150m (see Appendix A). The five testing vignettes were then socialized across the Army through multiple focus groups with combat-experienced Soldiers. The most difficult aspect of this developmental process was forcing participants to focus on individual Soldier performance vs. squad/buddy team performance. A good example was scaling a fixed vertical surface/wall. Virtually all respondents stated that 2m was the correct height for a fixed vertical obstacle. In a full fighting load (approximately 85lbs), scaling a 2m wall is a two-Soldier task. Respondents mostly agreed that few Soldiers could scale a 2m wall in full combat load as an individual task. As part of the distillation process (and based upon input from the focus groups and full consideration of the "baseline" nature of the study), the research team agreed on a modified fighting load weight for the study (between 45-55lbs (skin out)), and a fixed wall height of 54in. To complete Phase I, the research team field tested the WTBD-ST with Drill Sergeant Leaders at FT Jackson, SC in August, 2013, and Soldiers from the 3rd BCT, 4th ID, FT Carson, CO in September, 2013. Additional changes to the WTBD-ST, including drag and pull weights, high crawl distance and inter-obstacle distances, were made as a result of these field observations and feedback from Soldiers.

In Phase II (Predictive Validation), researchers administered the WTBD-ST and 23 common physical fitness test events[2] (predictor tests) to approximately 350 Soldiers from the 2nd BCT and Combat Aviation Brigade (CAB), 1st ID/FT Riley, KS. During the systematic review, researchers had identified five physical readiness constructs: (1) move quickly over, under, around, through obstacles; (2) lift, carry, drag heavy loads; (3) generate and apply force; (4) execute submaximal work for long periods; and (5) move for long distances over uneven terrain under heavy loads. These five physical readiness constructs aligned well with the five components of physical fitness established by the U.S. Army Research in Environmental Medicine (USARIEM) for the Soldier 2020/Physical Demands Study (2015): (1) speed/agility, (2) muscular strength, (3) explosive power, (4) muscular endurance, and (5) cardiovascular endurance. Analyses identified eight field-expedient tests that were both highly predictive of WTBD-ST performance, and that assessed the five components of physical fitness.

[2] The 23 physical fitness test events / exercises were selected by the research team composed of research physiologists and fitness experts across the Army. The intent was to select a comprehensive battery of physical fitness and skill-related fitness test events. As directed by Army Senior Leaders logistical (time) and equipment (cost) were not considered in the selection of the 23 test events.

In Phase III (Sequential Validation), researchers administered the eight physical fitness tests identified in Phase II to a sample of 165 Soldiers from the 3rd BCT, 3rd ID and Maneuver Center of Excellence (MCoE) at FT Benning, GA. The test events were administered sequentially to cohorts of approximately 45 Soldiers. Although there was no programmed rest between events, there was generally a 5-10-minute "wait period" between each event as Soldiers stood in line (4 Soldiers per lane) to take the next event. There were 10 testing lanes and 10 graders. Graders stayed with their "4-Soldier stack" throughout the test. The first Soldier in each "stack" across all 10 lanes tested together. All 40 Soldiers rotated to the next test event as a group. The average time required to test 40 Soldiers with 10 lanes on all eight events was ~75 minutes. Soldiers completed the WTBD-ST on a different day.

METHODS

Research Design/Summary

The Baseline Soldier Physical Readiness Requirements Study was a prospective study where Soldiers performed WTBD/CSTs and common fitness exercises while the research team observed their execution and recorded number of repetitions, distance, and/or time to execute.

Objectives/Specific Aims of the Study

(1) Determine the baseline physical readiness requirements of physically demanding, commonly occurring and critical Warrior Tasks and Battle Drills, Common Soldier Tasks.
(2) Determine the components of physical and motor fitness that strongly correlate with performance on Warrior Tasks and Battle Drills and Common Soldier Tasks.
(3) Determine the ability of the 3-event APFT to successfully predict performance on WTBD/CSTs.
(4) Determine the components of physical/motor fitness, as measured by field-expedient test events, which are most associated with successful performance on WTBD/CSTs.

Institutional Review Board – Human Subjects

From September to December, 2013, the BSPRRS research team prepared the research protocol for the Institutional Review Board (IRB). In consultation with Public Health Command (PHC), the decision was made to utilize the Medical Research and Material Command (MRMC) IRB as the IRB of record, and Public Health Center as the sponsoring agency. An experienced researcher on the BSPRRS team, MAJ David DeGroot (U.S. Army Public Health Center), served as the principal investigator for the IRB process. Following the protocol for the Physical Demands Study/Soldier 2020, the protocol IRB documents were developed for the predictive validation and sequential validation phases (Phases II and III of the study). In both phases Soldiers performed physical tasks similar to those they routinely execute while researchers observed their performance and recorded number of repetitions, time to execute, and performance feedback. Both protocols were evaluated by scientific advisors at PHC prior to submission to the MRMC-IRB. After the USAPHC Scientific Review committee had reviewed and approved the protocols, they were submitted to the MRMC IRB for research review and approval. The Phase IV study was assigned MRMC IRB number M-10408 and was approved on 8 September, 2014; Phase V study was assigned MRMC IRB number M-10432, approved on 8 March, 2015.

Data Analysis

Only complete records were used in the data analysis. For incomplete records with minimal missing data, researchers used mean/linear extrapolation to complete the record. Descriptive statistics (frequencies, distributions, means, and standard deviations) were calculated for all survey and APFT variables. A multivariate logistic regression model was used to estimate predictors of WTBD/CSTs performance in this population.

Multiple analyses were conducted for each phase of the study. To assess external responsiveness, researchers utilized a simple ANOVA to determine the sensitivity of the WTBD-ST to measure combat readiness among known groups. In the predictive and sequential validation analyses, researchers conducted a series of fully specified stepwise multiple regression analyses to estimate the contribution of each physical capacity measure to the variability of the composite WTBD/CSTs proxy simulation. Most regression analyses used the default stepping method criteria for including/excluding model terms (entry = .05 and removal = .10); however depending upon considerations related to enhancing extrinsic motivation or potential to "drive" training, a full regression model was used.

Based on current best practice for regression analyses, individual event scores were not analyzed or adjusted for distribution abnormalities, which is generally considered to be unnecessary with a least squares model (Fox, 2016). With direction from Army senior leaders, all regression analyses were conducted on the complete sample (both men and women). The reasoning was that baseline Warrior Tasks and Battle Drills and Common Soldier Tasks are criterion tasks that apply equally to men and women. In the first regression analysis, a composite WTBD-ST (the average for the fighting load trial and pre-fatigue trial) was regressed on test events from the Army Physical Fitness Test. In the second regression analysis, the composite WTBD-ST was regressed on the 23 physical fitness test events to estimate the magnitude of effect for each field-expedient fitness assessment. A sum of least squares model ($\alpha = .05$) was utilized to determine which field expedient tests contribute significantly to the overall variability of WTBD ST performance. This analysis allowed the researchers to formulate a baseline physical fitness battery similar to the Army Physical Fitness Test based upon the physical readiness requirements of the physically demanding, commonly occurring, and critical WTBD/CSTs. In the final sequential validation, composite WTBD performance scores were regressed on the eight most predictive test events identified in the predictive validation analysis.

Subject Population(s)

Based upon the specified tasks in HQDA EXORD 041-13, both TRADOC and FORSCOM proponents were tasked to identify target units to participate in the BSPRRS study. Over 1,000 Soldiers volunteered for the study. In the final analysis, 800 complete data records were recorded: 691 men (86%) and 109 women (14%) (See Table 2). All Soldiers assigned to the target units designated by TRADOC/FORSCOM had the opportunity to volunteer for and participate in the study. Volunteers were not screened in or out on the basis of gender, ethnicity, education, or any other socio-demographic variables. To avoid any potential conflict with Soldier leave, pass status, duty, training, schooling, or other key personal, professional, and/or training events, TRADOC/FORSCOM provided only Soldiers who were physically sound (non-profile/non-flagged) and for whom study participation did not pose an undue burden or inconvenience. Soldiers on a limiting profile and/or with flagging action were excluded from

the study. In order to avoid the appearance of coercion when soliciting voluntary participation, an impartial Ombudsman was appointed by the IRB and attended all informed consent briefings.

Testing Overview

Soldiers who volunteered for any phase of the Baseline Soldier Physical Readiness Requirements Study were given specific instructions related to additional physical activity, recovery time, nutrition, and hydration while in the study. A typical testing session lasted approximately 90 minutes. Each session started with a task-specific safety brief that identified threats, risks, and mitigation, and then proceeded to a proper warm-up, followed by a physical activity, followed by a cool-down/stretching session per FM 7-22. On days where two testing sessions were conducted, volunteers were given a minimum of four (4) hours rest between sessions so that they could recover, rehydrate and refuel. Soldiers were instructed not to participate in any other physical training/tasks during the study. Daily assessments were selected to minimize physiological interaction (e.g., a Soldier would not do modified sit-ups and the "ab rower" on the same day) and overall rigor. Medical personnel were present at every testing/practice session. In the event of inclement weather, the schedule was shifted within the day or week to ensure the safety of study volunteers and team members.

Soldiers at 1ID, FT Riley, Kansas (FRKS) and 3ID, FT Benning, Georgia (FBGA) were the primary test subjects. On Day 0, Soldiers were given the BSPRRS informed consent briefing. Soldiers who consented were provided additional administrative instructions and were placed in "squads" with an NCOIC and Research Monitor. Soldiers remained in their squad for the duration of the study. Prior to each test, Soldiers were given a safety/familiarization briefing. Upon reporting on Day 1, Soldiers submitted their most recent DD 705, Army Physical Fitness Test Scorecard; these three test events – push-up, sit-up and 2-mile run were included in the 23 fitness test events. On Day 1, morning, Soldiers were given a 3-hour orientation session to familiarize them with the WTBD-ST and 22 common physical fitness test events. Researchers explained and demonstrated each physical fitness test event. Soldiers were allowed to practice each event until graders deemed they were competent to safely execute each test event. The four WTBD-ST vignettes were taught by the "whole-part-whole" methodology: (1) build a hasty fighting position; (2) move over, under, around and through; (3) react to man-man contact; and (4) extract/evacuate a casualty. Soldiers, dressed in the Army Physical Fitness Uniform (APFU), practiced during the orientation session. On Day 1, afternoon, Soldiers executed five[3] physical fitness test events. On Day 2, morning, researchers conducted another instruction/practice session and Soldiers executed the WTBD-ST vignettes in Occupational Camouflage Pattern (OCP) / boots. On Day 2, afternoon, Soldiers executed five physical fitness test events. On Day 3, morning, Soldiers ran the WTBD-ST (the four field vignettes together) with a modified fighting load (35-45lbs). On Day 3, afternoon, Soldiers executed four physical fitness test events. On Day 4, Soldiers completed the 1600m loaded run/walk (in OCP/boots and a modified sustainment load - 55-65lbs) and proceeded directly to the four field vignettes of the WTBD-ST. On Day 4, afternoon, Soldiers executed four physical fitness test events. On Day 5, morning, Soldiers executed four physical fitness test events, thus, over the five days, completing a total of

[3] On Day 1 and Day 2 researchers used a strain gauge dynamometer to measure lower body leg press and upper body upright pull. The equipment proved unstable / unsuitable in a field environment and these two measures were excluded from the regression analysis. A total of 23 test was used in the regression analysis; 20 variables were tested in the field, plus the three APFT test events.

22 different physical fitness test events. The most recent APFT raw scores (DD 705) for 2-minute push-ups, 2-minute sit-ups and 2-mile run were provided by each Soldier on Day 1. Graded testing consisted of the WTBD-ST and 22 predictor tests. A summary of the WTBD-ST is presented in Appendix A, with diagrams in Figures 1, 2, and 3. The 23 field-expedient test events use in the regression analysis are provided in Table 3.

Testing Procedures

Criterion Measure Task Simulation: high physical demand WTBD/CSTs: To answer the questions posed in HQDA EXORD 041-13, it was first necessary to establish a functional representation (criterion measure) of the physically demanding WTBD/CSTs. The term we used for this criterion measure was the WTBD Proxy Simulation Test (WTBD-ST). Step 1 in the development of the WTBD-ST was to conduct a systematic review of previous literature coupled with an in-depth analysis of the approved Warrior Tasks and Battle Drills and Common Soldier Tasks. The systematic review was conducted by personnel at the Army Public Health Command. We also administered an Army-wide survey to ascertain Soldiers' opinions on Army physical readiness training and assessment. We specifically asked respondents to rank order the WTBD/CSTs in order of their physical demand, frequency of occurrence, and criticality to the combat mission. We also conducted two scientific working group sessions and three Army-wide focus groups to deconstruct the WTBD/CSTs. Based upon the systematic review, SME working group sessions, Army-wide survey, and Army-wide focus groups, 113 WTBD/CSTs were distilled to 11 tasks.

<u>Physically Demanding Warrior Tasks and Battle Drills</u>

1. 071-COM-0501 Move as a member of a Team
2. 071-COM-0541 Perform Exterior Movement Techniques- Urban Operation
3. 071-COM-0502 Move under Direct Fire
4. 071-COM-0510 React to Indirect Fire dismounted
5. 071-COM-0503 Move Over, Under, Around, Through, Obstacles
6. 081-COM-1046 Transport a Casualty
7. 071-COM-0006 React to Man-to-Man Contact
8. 071-COM-1006 Navigate point to point dismounted

<u>Physically Demanding Common Soldier Tasks</u>

9. Conduct Dismounted Tactical Foot March
10. Prepare a Fighting Position (Fill and Emplace Sandbags)
11. Drag a Casualty to Immediate Safety-Mounted

During a two-day SME working group session in May, 2013, the BSPRRS working group deconstructed the 11 WTBD/CSTs based upon the biomechanical and physiological components of these tasks. After eliminating redundancies, the 11 WTBD/CSTs were distilled down to five composite warrior tasks, which were identified by the following operational terms:

1. Move over, under, around, through obstacles (on uneven/urban terrain)
2. React to close quarters contact (conduct combatives)

3. Conduct loaded, dismounted foot march (move point to point over uneven terrain)
4. Prepare a fighting position (dig/fill/carry/stack sandbags)
5. Extract a casualty and drag to safety

In June, 2013, a subgroup of the BSPRRS working group convened at FT Eustis to develop functional representations of the five physically demanding, common and critical warrior tasks. A proxy simulation was developed for each warrior task that used commonly available materials and was portable. For composite testing, the vignettes were aligned in such a way to follow a reasonably intuitive order of events for a combat mission: 1- move to the objective, 2- build a hasty fighting position upon contact, 3-move over/through obstacles on the objective, 4- react to close quarters contact, 5- extract a casualty, transport/drag to safety, and break contact.

WTBD Simulation Test (WTBD-ST) Descriptions: The WTBD-ST developed in Phase I of the BSPRRS study was composed of five warrior task simulations. The five criterion task vignettes were identified by an abbreviated term: pre-fatigue (foot movement over long distance under load), fighting position (build a hasty fighting position), move O-U-A-T (move over-under-around-through obstacles), combatives (employ progressive levels of force (close quarters combat)), and casualty evacuation (casualty extraction and transport/drag). The four "field events" were scored (timed) as discrete events that were summed together as a composite task. The total time to execute the four field WTBD-ST vignettes was used as the criterion task in the regression analyses. A detailed description of the metrics/measurements for each vignette in the WTBD-ST is presented in Appendix A.

Independent/Predictor Variables: Based upon the systematic review and the focus group/ survey responses in Phase I, the following 23 common field-expedient test events[4] were selected for this study. Testing descriptions are presented in Table 3.

Measures of Muscular Strength:

1. 80lb Sumo Squat
2. Bench Press Strength
3. Hexagon bar Deadlift
4. Leg Tuck
5. Pull-ups

Measures of Explosive Power:

1. Standing long jump
2. Vertical jump
3. 20lb Power Throw
4. 50yd Sled Push
5. 50yd Power Drag

Measures of Muscular Endurance (Core, Upper Body, Lower Body)

1. Dips
2. Bench Press Endurance
3. Push-ups

[4] The 23 physical fitness test events were selected by the research team composed of research physiologists and fitness experts across the Army. The intent was to select a comprehensive battery of physical fitness and skill-related fitness test events. As directed by Army Senior Leaders logistical (time) and equipment (cost) were not considered in the selection of the 23 test events.

4. 40lb kettlebell Squat
5. Modified Sit-ups
6. Weighted Trunk Rotations
7. Abdominal Rower
8. Sit-ups

Measures of Cardiovascular Endurance

1. 2-mile Run

Measures of Speed/Agility

1. 21-pound Loaded 300yd Shuttle Run
2. 300yd Shuttle Run
3. Illinois Agility Test
4. 400yd Sprint

Research Phases

Assessing Face Validity: By August, 2013, the BSPRRS team finalized the five functional vignettes for the WTBD-ST and conducted the first validation field trails at FT Jackson, SC. The purpose of these trials was to obtain feedback (face validity) on the WTBD-ST. Participants were primarily Drill Sergeant Leaders and senior NCOs with significant combat experience. The Drill Sergeant Academy was the primary support element and supplied most of the participants. Twenty-four Soldiers volunteered to participate in three days of assessments. On Days 1 and 2, participants spent approximately four hours per day learning/practicing the four "field" vignettes (fighting position, move OUAT, combatives, and casualty evacuation).; Day 1 practice was conducted in in APFU, and Day 2 in ACU/boots. During the practice session, researchers tested various weights, distances, and number of repetitions to ensure the WTBD-ST simulated performance of the physically demanding, commonly occurring, and critical WTBD/CSTs. On the final day, volunteers conducted a 10k loaded ruck march (45-55lbs) to simulate movement to the objective and then immediately engaged the WTBD-ST. Group and individual after-action-reviews (AAR) were held with the volunteers to ensure researchers captured recommended changes to the WTBD-ST. A specific example of an administrative change to the WTBD-ST based on the FJSC testing was to the "crawl" event in the move OUAT. Originally, there were two 20m low crawls in the move OUAT vignette. Based on the overall demands of the WTBD-ST, the distance and number of repetitions was deemed too demanding and the low-crawl was changed to a high-crawl and reduced to one 10m event.

Assessing Content Validity: The purpose of the FT Jackson testing was to develop a 90% solution to the WTBD-ST that could be administered to a larger, more heterogeneous Army population. In September, 2013, the BSPRRS team went to FT Carson, CO where approximately 250 Soldiers ran the WTBD-ST under four discrete conditions as part of their physical readiness training program: (1) in APFU, one "field" vignette at a time, (2) in ACUs, running the four "field" vignettes as a composite task, (3) in ACUs running the four "field" vignettes as a composite task with a modified fighting load (approximately 40-50lbs), and (4) in ACUs running the four "field" vignettes as a composite task with a modified fighting load following a 10k road march in a modified sustainment load (approximately 55-65lbs – see Table 4). FT Carson personnel timed each Soldier as they engaged the WTBD-ST. At the end of each

week, Soldiers voluntarily completed an AAR survey that asked specific questions about loads, distances, weights, and repetitions in the WTBD-ST. Several minor modifications were made to the WTBD-ST following the testing at FT Carson. Two of the most significant changes were to the "movement to the objective" and "casualty evacuation" vignettes. The purpose of the 10k road march was to simulate two WTBDs: navigate point-to-point over uneven terrain and conduct a tactical foot movement. The 10k road march was intended to mirror the physical pre-fatigue created by moving over uneven terrain to the objective. With the self-paced 10k movement in the modified sustainment load, the road march was not rigorous enough; exercise heart rates were approximately 130bpm with 12-13 RPE. In all subsequent testing at FT Benning and FT Riley a 1600m loaded walk/run in the same 55-65lb load was used as the pre-fatigue/movement requirement. Volunteers were asked to complete the 1600m as quickly as possible. For the casualty extraction - evacuation vignette we used an actual Humvee for the extraction phase. The reset time to get the combatives dummy under load back into the Humvee was so long as to be impractical for later testing. We changed the casualty extraction to a wooden "bench seat" and later to a 48" high, flat table with a 2x2 wooden rim, which forced Soldiers to lift and lower the casualty to the ground before dragging to safety.

Assessing External Responsiveness: As the first step in the external validation process, in March, 2014, the BSPRRS team conducted an assessment of external responsiveness for the WTBD-ST. External responsiveness assesses a test's ability to discriminate between different performance levels. During three 90-minute training sessions, 34 Soldiers from the 3rd Battalion, 75th Ranger Regiment ran the WTBD-ST under three conditions: 1- in ACUs, running the four "field" vignettes as a composite task, 2- in ACUs running the four "field" vignettes as a composite task with a modified fighting load (approximately 40-50lbs), and 3- in ACUs running the four "field" vignettes as a composite task with a modified fighting load (approximately 40-50lbs) following a 1600m loaded run in a modified sustainment load (approximately 55-65lbs).

Assessing Predictive Validity: After the research protocol was approved by the MRMC IRB, the BSPRRS team conducted the predictive validation testing at FT Riley, KS in September 2014. A classic predictive validation design was utilized. The WTBD-ST was used as the criterion measure for WTBD/CSTs, and the 23 common field expedient physical fitness test events were used as the predictor variables. Volunteers from the 2nd Brigade Combat Team (BCT) (week 1) and the 1st Combat Aviation Brigade (CAB) (week 2) participated in these assessments. To minimize time away from their duties, AM/PM testing sessions were conducted Monday – Friday. After proper instruction and practice, volunteers ran the WTBD-ST in the AM sessions under four conditions: 1- in the APFU, one vignette at a time, 2- in ACUs, running the four "field" vignettes as a composite task, 3- in ACUs running the four "field" vignettes as a composite task with a modified fighting load (approximately 40-50lbs), and 4- in ACUs running the four "field" vignettes as a composite task following a 1600m loaded walk/run in a modified sustainment load (55-65lbs). During the afternoon sessions, volunteers tested on 4-5 common physical fitness test events. These tests were matched by rigor with the AM-PM session exercises to avoid undue fatigue and physiological interference. For example, the 23 field expedient test events include four core endurance assessments (modified sit-ups, AB rotations, rower, and leg tuck); only one core endurance test event was schedule each day. The physical fitness test events were common-place exercises that are routinely administered to Soldiers during training as part of FM 7-22 – Army Physical Readiness Training (see Table 3).

Assessing Sequential Validity: Due to limited time availability for Soldiers at FT Riley, KS, researchers administered the 23 physical fitness test events during 2-hour periods over four days. Once the initial battery of test events was identified, it was important to re-validate their predictive validity by administering each test event sequentially during a single testing period of 60 to 75-minutes. The purpose of the sequential validation was to determine the influence of a continuous, serial administration of test events on WTBD-ST prediction. The second research protocol was approved by the MRMC IRB, and the BSPRRS team conducted the sequential validation testing at FT Benning, GA in March, 2015. A single convenience sample of 152 Soldiers from the 3rd Armor Brigade Combat Team/3rd Infantry Division and the Maneuver Center of Excellence participated in the sequential validation. Access to the FT Benning, GA Soldier sample was also limited to four 4-hr testing blocks over four days, Monday –Thursday. Based upon the results from the predictive validation testing at FT Riley, eight predictor variables were identified as most predictive of WTBD-ST performance. The eight variables were: 50yd sled push, 2-minute push-up, 50yd load drag, 20lb power throw, 3 repetition maximum (RM) deadlift, 300yd shuttle run, leg tuck, and 2-mile run. In order to assess the relationship between the serial administration of the eight physical fitness test events and performance on the WTBD-ST, volunteers also ran the WTBD-ST, but only under fighting load.

On Day 1, volunteers (in APFU) executed the eight physical fitness exercises described above. Following a short rest, Soldiers participated in a demonstration and practice session for the four WTBD-ST "field" vignettes. After an additional warm-up/practice period on Day 2, volunteers ran the four "field" vignettes of the WTBD-ST as a composite task in ACUs. On the morning of Day 3, volunteers ran the four "field" vignettes as a composite task in a modified fighting load (approximately 45-55lbs). Although the 1600m pre-fatigue affected absolute WTBD-ST performance, the correlation between WTBD-ST performance with and without the pre-fatigue were basically linear ($r > .83$). Since the 1600m run/walk effect was relatively linear across measures, due to testing time restrictions for the FT Benning sequential validation, we did not execute the pre-fatigue trails. On Day 4, volunteers executed the eight physical fitness tests in the APFU. The eight physical fitness test events described above were re-administered in under the same testing protocol and conditions.

RESULTS AND DISCUSSION:

Due to the iterative nature of the BSPRRS research process, the results will be presented and discussed by area of analysis. The five areas are: face validity, content validity, external responsiveness, predictive validity, and sequential validity.

External Responsiveness Analysis

Face and Content Validity Analysis. The first question posed in HQDA EXORD was determine the physical requirements of the physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills and Common Soldier Tasks. In Phase I of the Baseline Soldier Physical Readiness Requirements Study, the research team compiled a list of the physically demanding, commonly occurring, and critical warrior tasks and battle drills/common soldier tasks. Working with the results of the annual Soldier Survey, the research team,

consisting of combat-experienced Soldiers and physical development experts, eliminated redundant tasks, deconstructed the remaining WTBD/CSTs tasks into their component physical demands (e.g., sprinting, lifting, jumping, climbing, etc., in accordance with physical demand criteria in DA PAM 611-20), and assigned initial physical demand requirements (e.g., weights, distances, heights, speeds, etc.). As part of the survey/focus group data collection process, Soldiers were asked to describe the physically demanding tasks they performed as Soldiers, specifically while deployed. They were asked to rate task difficulty and frequency, which were then validated by four focus groups:

Focus Groups Comments / Highlights:

What is the importance of each domain of fitness?

- Muscle Strength: is most important domain for WTBD but current PRT does not emphasize and the APFT does not assess; muscular strength is just as important as aerobic endurance; you have to have the strength to carry a load; I'm a small person so I have to focus more on strength.
- Muscular Endurance: these kinds of exercises do not require much equipment, but tend to get monotonous that increases the need for variety; get rid of sit ups.
- Aerobic Endurance: if you're trying to keep people fit you need to do aerobic activities as well as eat a good diet; long runs build mental toughness; running 2-3 miles doesn't translate into any Army activity; longer runs are more for building mental fitness than combat related; running in formation is the worst thing you can do.
- Anaerobic Endurance (Speed): doing short sprints within longer aerobic activities is probably a good way to train; 400yd is the max for anaerobic endurance.
- Anaerobic / Explosive Power: explosive power is probably best learned by gaining muscular strength and practicing tire flips, one rep lifts, and maybe sled pushing.
- Core Strength: this is a vital part of overall muscular strength and endurance; it's the lynchpin for doing the other physical activities; core is center of everything - you can't have a good solar system with a really small sun.
- Mobility: is important in preventing injury while doing other activities; need more lateral movements, not forward motion; more lateral movements – flexibility, yoga.

What are the best exercises for each Fitness domain?

- Strength: deadlift/back squat, bench press; Secondary – kettlebell, power clean,
- Muscular Endurance: air squats, pushups; Secondary – sit ups, pull ups.
- Aerobic Endurance: run 4-6 miles to train for technical foot march
- Anaerobic Endurance (Speed): 300yd shuttle run, 400yd sprint/intervals; Secondary – 60s-120s, last man up, interval sprinting, burpee
- Explosive Power: sled push/pull, tire flip; Secondary – smash balls, box jumps
- Core Strength: leg throw downs, planks
- Mobility/Agility: speed ladders, agility runs

Does your unit have access to resources to train in the seven domains?

- If fitness is so important, why isn't equipment available?
- We have the resources for everything but strength exercises. We don't have access to gym during PT time. I can't get a full body workout with jugs and sandbags. Resources need to be directed to muscular strength.
- Would be nice to work on strength instead of doing PT every day.
- 0630-0830 gym is closed for PRT; can't go to gym during PT time; my unit is not allowed to go to the gym during PT hours.
- Not enough equipment in gym. Gym availability is a huge issue. Half units don't have equipment. Most units don't have enough money to buy equipment.
- Find a way to punch card during PT at gym to show commander you did it so you can tailor your workout to yourself. There is a way for units to get weight rooms.

Based upon the underlying analysis of the component tasks and the focus group feedback, the WTBD/CSTs were distilled from 113 tasks to 11 high-demand tasks. The research team further deconstructed each of the 11 high-demand warrior tasks to determine task overlap. Ultimately, five (5) high physical demand constructs were identified (movement under load, build a hasty fighting position, movement rapidly over/around obstacles, employ progressive levels of force, and casualty extraction / evaluation). During the second part of Phase I, the research team developed a field-expedient simulation (WTBD-ST) designed to measure these five combat tasks. Subsequent focus groups reviewed the field simulation test and provided critical feedback that was incorporated into the design. The WTBD-ST was field tested at the US Army Drill Sargent School, which resulted in additional modifications.

Assessing Content Validity. The purpose of the FT Carson testing was to establish the face and content validity of the WTBD-ST, and to answer the first question posed by HQDA EXORD 041-13 – what are the physical readiness requirements of WTBD/CSTs? The WTBD-ST was administered to a sample of 264 Soldiers from the 3rd BCT/4th ID (males = 224; females = 40). They represented a myriad of combat and non-combat military occupational specialties (MOS) from throughout the brigade combat team (BCT). Upon completing four days of testing Soldiers were asked to complete a survey.

Soldier Ranking of Most Difficult Physical Tasks (FT Carson, SEP 2013)

Following a day of instruction and practice, all Soldiers executed the WTBD-ST under three discrete conditions. For the first WTBD-ST trial, Soldiers wore the Army combat uniform and boots ("ACU only"), on Day 2 they added a modified fighting load weighing 40 to 50lbs ("Fighting Load"), and on Day 3 they completed the WTBD-ST wearing the modified Fighting Load after completing a 10km road march wearing a modified sustainment load (55-65lbs). Each day after conducting the WTBD-ST, Soldiers were asked to rank up to the top 2-3 most difficult sub-tasks of each of the 4 broader WTBD-ST "field" vignettes.

These ranks provided a descriptive assessment of Soldiers' task perceptions. Additional anecdotal comments provided insights as to difficulty of performing the various subtasks. Rank scores, obtained separately for both weeks, were combined. Because some Soldiers did not always identify more than one sub-task, the 1-3 ranks for each day were totaled to evaluate

overall trends. Individual percentages for daily task, subtask, and separate 1, 2, and 3 ranks were also calculated.

Table 5 depicts the combined percentages of the top ranked composite tasks for each day by perceived level of difficulty. While the "Perform Combatives" composite task was consistently noted as the most difficult, it incorporated 4 distinct subtasks (more than any other composite Task). Of these sub-tasks, the SKEDCO[5] pull was consistently identified as the most difficult. This sub-task was similar to, or slightly less difficult than, the Casualty Rescue Task (extricate and drag subtask). Perceptions of task difficulty were similar each day with two notable exceptions: (1) the Fighting Position task (specifically the subtask of stacking sandbags) was ranked notably more difficult on Day 3 after the road march, and (2) Soldiers reported less difficulty overall on Day 3 on tasks that had previously been ranked as difficult (e.g., SKEDCO pull, trashcan turn, and casualty evacuation), perhaps due to familiarization and improved technique.

WTBD-ST Event Analysis (FT Carson, SEP 2013)

Though SKEDCO pull and Casualty evacuation were deemed most physically-demanding, the similarity between them suggested that only one of these events was needed to 'test' a Soldier's capability to drag a casualty some distance. Across tasks, fatigue was not always the reason given for "difficulty." More problematic were environmental conditions (e.g., on Day 2 wet sand made sand heavier in bags, SKEDCO, and trashcan more difficult and the wet ground was more difficult to get traction/footing) and equipment (e.g., body armor and ammo pouch worn on chest were in the way during sandbag stack and wall climb for shorter persons, and carrying a the slung weapon was a hindrance). On the other hand, some of same factors were noted as reasons that certain tasks/subtasks became easier. For example, some persons indicated the crawl, SKEDCO pull, and trash can spin were easier on damp ground. Some persons of shorter stature said the addition of the fighting load made SKEDCO pull seem easier. On Day 3, some noted difficulty on road march due to blisters from the boots. Finally, while rankings from females were not gathered separately for analyses, anecdotally women's concerns related to effects of height and body mass. Taller/higher body mass Soldiers did not identify the same problems.

Overall, Soldiers felt they worked "hard" when taking the composite WTBD-ST (see Table 6). Using Borg's original perceived exertion scale (RPE, 6 = resting/no physical effort to 20 = the hardest physical thing I've ever done), the average RPE for the composite WTBD-ST was 16.46, which would correspond to a work heart rate of 165-170 beats per minute or approximately 85% of maximum heart rate (see Figure 4). In an attempt to improve the WTBD-ST, determine perceptions of event difficulty, and physical demands, Soldiers were asked to complete a short AAR survey upon completing Day 4 testing. Overall, Soldier responses to the WTBD-ST were positive. Three representative comments were (which confirm the 16+ average RPE): (1) "this was extremely challenging and very tough", (2) "this course is the best example of our everyday tasks conducted down range and our everyday tasks. This is the best realistic course I have ever been in", and (3) "this was pretty much fun and exciting while challenging at the same time." Some suggestions to improve the WTBD-ST were: add more vertical walls and

[5] a SKEDCO is a semi-rigid, plastic sled designed to skid across all types of terrain carrying a heavy load (i.e. wounded Soldier)

ropes, increase the weights/loads, make the lanes longer, add 800m run to the end of the course, and improve the low obstacles.

The first research question posed in HQDA EXORD 041-13 was to determine the physical readiness requirements of Warrior Tasks and Battle Drills and Common Soldier Tasks. In the final analysis of FT Carson data, researchers partitioned the physical components of the WTBD-ST by physiologic demand (muscular and cardiorespiratory). The three muscular functions were anaerobic power, muscular endurance, and muscular strength. Although some of these components overlap physiologically, assessments of time and intensity allowed researchers to assign micro-segments of the WTBD-ST to one of these four components. The muscular demands as a percentage of time-on-task for the WTBD-ST were: muscular endurance - filling buckets (38%), muscular strength - lifting sandbags (31%), and anaerobic power - dragging a casualty (31%); see Figure 5. When events were partitioned by cardiorespiratory demands (i.e., aerobic and anaerobic pathways), the percentage time on task was: aerobic (61.4%) and anaerobic (38.6%). These notions of work requirements should be central in the development of Soldier physical readiness training programs.

External Responsiveness Analysis

Discriminant validity is the notion that theoretically spurious variables are in fact unrelated; and the criterion measure does verify / validate known differences. A method of measuring external responsiveness is through discriminant validation. The WTBD-ST was developed as a criterion measure of WTBD/CSTs performance based upon the extensive analysis and recommendations by exercise scientists and military subject matter experts. Although the face validity of the WTBD-ST was confirmed through multiple focus groups, empirical observations of Soldier performance, and feedback from two samples (FT Jackson, SC – Drill Sergeant Academy, FT Carson, CO – 4th ID), researchers conducted an external responsiveness analysis by comparing group performance with a criterion performance sample. Two comparisons were conducted. First, male Soldiers from the 1st BCT / 4th ID were compared to a criterion sample of Soldiers from the 3rd Battalion / 75th Ranger Regiment at FT Benning for the WTBD-ST. Based upon mission parameters, training regimens, and training support, researchers hypothesized a statistically significant difference in WTBD-ST performance between these groups in ACUs, in a modified fighting load (40-50lbs), and in a modified fighting load following a 1600m loaded ruck run (55-65lbs).

The Soldiers in the 75th Ranger Regiment represent the pinnacle of military tactical fitness in the Army and therefore their WTBD-ST scores should significantly exceed those of any other unit (i.e., if externally responsive, WTBD-ST performance should be significantly different for these two groups). As expected, the performance of Rangers and 4th ID Soldiers on the WTBD-ST was significantly different across the three conditions, and these differences increased with additional demand (Δ ACU = 2:03; Δ Fighting Load = 3:55, and Δ Fighting Load following pre-fatigue = 4:44). Lastly, the Δ 1600m run time for 1st ID men (12:05) v. 3rd Battalion / 75th Ranger Regiment (9:37) = 4:20. Accepting the fact that Soldiers in the Ranger Regiment have significantly greater opportunities to train with better facilities, equipment, and support personnel, and more rigorous physical expectations and assessments, the WTBD-ST clearly demonstrated a high level of external responsiveness (see Table 6) as substantiated by these significant differences.

In the second comparison, WTBD-ST times in fighting load ("Day 2") were compared for males across all four samples: 3rd Battalion / 75th Ranger Regiment, 3rd ID/MCoE – FT Benning, 1st ID – FT Riley and 4th ID – FT Carson. There was a statistically significant performance difference among and between groups; $F = 109.609$, $p \leq 0.000$ (see Tables 7, 8, 9). A high level of external responsiveness for the WTBD-ST is supported by the significant differences between the WTBD-ST scores for Soldiers from the four samples.

Based upon the Army-wide Soldier Survey, multiple focus groups, WTBD-ST field testing, and the external responsiveness analysis, researchers were confident they had developed a valid and reliable criterion assessment of the physically demanding, commonly occurring and critical WTBD/CSTs. Based upon the observations and feedback from Soldiers at FT Jackson and FT Carson, the following changes were made to the WTBD-ST prior to the validation analysis:

- eliminate one of the high crawl elements
- reduce the casualty evacuation drag weight to 185lbs
- change the combatives SKEDCO pull element to a prowler sled push (this change was field tested with the 3rd Battalion / 75th Ranger Regiment Soldiers)
- remove the HUMVEE from the WTBD-ST and substitute a 48" wooden platform with a 2"x2" rail around the platform to force Soldiers to lift – lower the "casualty"
- replace the 2nd 42" low wall obstacle from the move O/U/A/T with a 36" high window (39" x 48")
- lengthen the high crawl "tunnel" from 5' to 10'

Predictive Validation Analysis

The predictive validation analysis was conducted to assess whether common physical fitness test events can accurately explain the performance variability for a criterion performance measure, in this case the ability to execute WTBD/CSTs in the form of the WTBD-ST. A common method of assessing predictive validity is to compare concurrent performance on a dependent criterion measure (WTBD-ST) to independent predictive measures (common physical fitness test events). This methodology is commonly used to identify field-expedient measures that can serve as proxy assessments for more time-, equipment-, and labor-intensive measures (e.g., skinfold measures as a proxy for DEXA body composition, 2-mile run as a proxy for laboratory measures of peak VO_2, etc.). Since a criterion measure for WTBD/CSTs performance did not exist, researchers developed the WTBD-ST and established face and content validity with strong external responsiveness in Phases I of the BSPRRS study.

The first part of the predictive validation analysis was to develop a list of "predictor" variables; these were common field-expedient physical fitness tests researchers expected would accurately represent/predict a Soldier's ability to perform physically demanding WTBD/CSTs. A reasonable assertion is, "just use the criterion variable to assess performance." There are a myriad of reasons not to use the criterion variable, but the most common is cost in terms of time, money, space requirements, equipment, and complexity of administration. In this particular case, the WTBD-ST takes considerably more time, space, equipment, and personnel to set-up and administer than common physical fitness test events. Moreover, the complexity of the WTBD-ST would attenuate score reliability in a non-research setting. The predictive validation

process involved estimating a linear stepwise model, regressing the WTBD-ST on the 23 common physical fitness tests. Physical performance data of 324 Soldiers from 1st ID at FT Riley were used in this analysis. Physical performance data were collected over a five-day period with two sessions per day from 14-27 SEP 2014. Soldiers trained on and executed the WTBD-ST in the morning, and then trained on and executed 4-5 physical predictor tests in the afternoon. There was a minimum of 4 hours rest/recovery between the two sessions. Morning and afternoon sessions were sequenced to minimize conflicts in level of intensity and physiological interactions. The uniform for the morning sessions was: ACU, boots, ACH, IOTV, hydration bladder, and weapon. Fighting load weights averaged between 40-50lbs (including ACU and boots) and sustainment load weights (for the 1600m run/walk) averaged between 55-65lbs. Skin-out weights averaged 42lbs in the fighting load to 62lbs in the sustainment load for the sample. Weights varied by Soldier ($\pm$ 5lbs) depending upon the size of the boots/plates. The uniform for the afternoon sessions was the Army Physical Fitness Uniform (APFU).

Demographic and Descriptive Statistics – 1st ID, FT Riley, KS

The FT Riley sample consisted of 290 males and 49 females. All Soldiers volunteered to participate in the study and provided informed consent as required in the research protocol approved by the MRMC IRB. Approximately 175 Soldiers participated on Week 1 and 175 Soldiers participate on Week 2. The average age, height, and weight data were collected on Day 1 of each week (see Table 10).

Following the Monday teach-train-practice session, WTBD-ST data were collected in three morning sessions (Tuesday, Wednesday, and Thursday). On Tuesday, Soldiers ran the WTBD-ST "field" vignettes (hasty fighting position, move OUAT, combatives, and casualty evacuation) as a composite task in ACU/boots. On Wednesday, Soldiers ran the WTBD-ST "field" vignettes as a composite task in ACU/boots and a modified fighting load. On Thursday, Soldiers ran the WTBD-ST "field" vignettes as a composite task in ACU/boots and a modified fighting load following a 1600m ruck run/walk. Run times (minutes) for the four "field" vignettes ranged from: Fighting Position – 4:30 to 9:00, Move OUAT – 1:30 to 4:30, Combatives – 1:30 to 4:30, Casualty Evac – 1:00 to 3:30, and Total Time – 9:00 to 22:00. The average run times for the pre-fatigue 1600m loaded ruck run/walk (Thursday) were: men = 12:05, women = 15:04. For reference, the average 1600m loaded ruck run/walk times for the Ranger sample from 3rd Battalion / 75th Ranger Regiment was 9:37 minutes. All WTBD-ST split and composite times are presented in Table 11.

The descriptive statistics for the 23 common physical fitness test events are presented in Table 12. These data were collected in four afternoon sessions (Monday, Tuesday, Wednesday and Thursday) and one morning session (Friday). Four to five test events were administered during each session. Test events were selected to minimize inter-day and intra-day physiological interference. The descriptive statistics are presented by event for males (M), females (F), and combined (C). These data are unremarkable and represent performance ranges expected by healthy, young adults.

Due to minimal training time on the strength deadlift and bench press, researchers selected a multiple repetition maximum approach to strength assessment to address safety concerns about untrained Soldiers attempting a maximum deadlift. Post hoc, a 1 repetition-maximum (1RM)

statistic was computed for the deadlift and bench press strength measures. Soldiers were directed to select a weight that would allow them to execute ≤ 6 repetitions of the two strength events. Reynolds, Gordon, and Robergs (2006) reported that 1RM prediction was more accurate with 5 maximal repetitions. According to Woods, Maddalozzo and Harter (2002), the Mayhew, Ball, Arnold, et al. (1992), Epley (1985), and Wathen (1994) [1RM prediction] formulas evidenced the lowest average error (AE) and highest relative accuracy over the resistance exercises examined. Researchers selected the Wathen 1RM formula to convert the deadlift and bench press scores to ~1RM. The ~1RM scores were used in the physical fitness test event validation analysis.

Physical Fitness Test Event Validation – FT Riley, KS

The first step in the predictive (concurrent) validation analysis was to finalize the criterion score (dependent variable). Researchers ran two test trials of the WTBD-ST in fighting load (without pre-fatigue and with pre-fatigue). Although the bivariate correlation coefficient between the WTBD-ST in fighting load and WTBD-ST in fighting load following the pre-fatigue (1600m ruck run/walk) was r = 0.833, there was significant discussion among the researchers and Soldiers about which trial best represented general WTBD/CSTs performance at the point of contact. Even though there was an absolute performance difference between the "field test" vignette times for the two conditions (fighting load = 13:26; pre-fatigue = 14:42, see Table 12), this difference was relatively linear as supported by the magnitude of the bivariate correlation coefficient. Many missions require Soldiers to fight dismounted at the point of contact, while other missions require Soldiers to move some distance over uneven terrain to an objective before executing the mission. As presented, both WTBD-ST conditions represent potential combat scenarios. To provide the most comprehensive assessment of WTBD/CSTs performance, researchers computed the average of the two trials (modified fighting load with no pre-fatigue, modified fighting load with pre-fatigue carrying a modified sustainment load) as the WTBD-ST independent variable.

In the first analysis, the average WTBD-ST score was regressed on the three events of the current Army Physical Fitness Test (APFT) (n_{male} = 278; n_{female} = 46; n_{total} = 324). The generally accepted industry standard for explained variance in multiple regression models (R^2) is ≥ .70, or 70%. Based upon findings for the FT Riley sample (see Table 13), the 3-event APFT is a relative moderate predictor of a Soldier's ability to execute high physically demanding WTBD/CSTs (R^2 = 0.423, $p<0.01$).

The purpose of the predictive validity analysis was to establish a subset of the fitness test events with content, construct, and predictive validity that could be administered serially as a test battery in the sequential validity analysis. In the second analysis, the average of WTBD-ST performance in fighting load and following a 1600m pre-fatigue was regressed on the 23 physical fitness test events. The stepwise linear regression model identified eight variables that accounted for a relatively high percentage of explained variance for WTBD-ST performance; R^2

$^{=}$ 0.737; $p \leq 0.05$ (see Table 14)[6]. The eight variables were: sled drag, power throw, 2-mile run, deadlift, sled push, leg tuck, kettlebell squat, and push-up.[7]

Sequential Validation Analysis

Following the completion of the predictive validity analysis, the Baseline Soldier Physical Readiness Requirements Study team conducted a 2-day workshop to plan the sequential validation analysis data collection. The focus of the workshop was on testing protocol and construct assurance. In conjunction with the Physical Demands Study/Soldier 2020[8], the working group identified five physical fitness constructs: muscular strength, muscular endurance, cardiovascular endurance, speed/agility, and power. There was significant discussion by the military and civilian SMEs concerning construct assurance of the predictor variables and their physiological interaction when administered sequentially as a "test."

Most of the discussions centered on the fact that the predictor variables for the FT Riley sample were collected over multiple days. This issue was manifest when both the 2-mile run and the 40lb kettlebell squat repetitions to fatigue (RTF) loaded in the model. Although the 2-mile run is primarily a measure of aerobic endurance, there is an inherent lower body muscular endurance component similar to the 40lb kettlebell squat RTF. Army leadership was also concerned that these eight fitness test events did not represent all components of physical fitness and therefore would not drive a comprehensive change in physical readiness training to increase combat lethality and potentially reduce musculoskeletal injuries (MSK-I).

After reviewing the FT Riley data analysis, Army leadership were concerned about the lack of an anaerobic endurance test event. This issue was more problematic since the 400m sprint loaded in the full regression model when the WTBD-ST scores for only the fighting load trial was used[9]. Therefore, the 40lb kettlebell squat was replaced by the 300yd shuttle run and forced into the model. In the full model regression with eight predictor variables presented in Table 15, $R^2 = 0.737$; $p \leq 0.05$: sled drag, 2-mile run, sled push, deadlift, push-up, leg tuck, 300yd shuttle run, power throw.

The FT Benning sample consisted of $n_{male} = 136$, $n_{female} = 16$, $n_{total} = 152$. All Soldiers volunteered to participate in the study and provided informed consent as required in the research protocol approved by the MRMC IRB. The average height and weight were collected on Day 1 (see Table 16). Following the Monday morning teach-train-practice session, the eight (8) physical fitness test event data were collected on Monday afternoon and again on Thursday afternoon. The descriptive statistics for the eight test events are presented in Table 17. These data are unremarkable and represent performance ranges expected by healthy, young adults.

[6] This full regression model for all eight (8) fitness test events utilized an average of WTBD-ST times for Fighting Load (FL) and 1600m Pre-Fatigue (PRE). When analyzed independently, the $R^2_{FL} = 0.723$ and $R^2_{PRE} = 0.632$.

[7] Following an external review by the University of Iowa, Virtual Soldier Research Center, reviewers suggested we bootstrap additional women into the FT Riley sample to provide a more balanced model and determine if women used a different solution set for WTBD-ST performance. After randomly bootstrapping 92 women into the sample ($M_n = 278$, $F_n = 138$) the R^2 increased slightly to 0.790 and the following fitness test events loaded into the regression model: sled drag, power throw, 2-mile run, deadlift, sled push, leg tuck, goblet squat, push-up.

[8] The Physical Demands Study (Soldier 2020) was initiated to answer the questions proposed in HQDA EXORD 112-13 - Army Required Actions in Support of the Elimination of the Direct Ground Combat Assignment Rule (DGCAR).

[9] The R2 full regression model for the fighting load = 0.723 for 7 fitness test events: sled drag, power throw, 400m sprint, deadlift, 2MR, sled push, leg tuck.

On Tuesday afternoon, participants ran the WTBD-ST "field" vignettes (hasty fighting position, move OUAT, combatives, and casualty evacuation) as a composite task in ACU/boots. On Wednesday afternoon, participants ran the WTBD-ST "field" vignettes as a composite task in ACU/boots and a modified fighting load. Total WTBDs run times (minutes) for ACU/boots = 5:49 to 13:16; and for ACU/boots/fighting load = 6:26 to 15:08 (see Table 18).

Since subjects were relative unfamiliar with the eight physical fitness test events, to maximize external validity of the regression analysis, the eight test event scores from Monday and Thursday were averaged for the dependent variable. Although distributions for the independent and dependent variables varied from slight to moderate skewed, they were representative of the population distributions for Soldiers. Therefore, researchers conducted a full model regression analysis utilizing the empirical raw scores. The four most predictive independent variables were: sled drag, 2-mile run, power throw, 1RM deadlift; $R^2 = 0.832$; $p \leq 0.05$ (see Table 19). The full model for all eight (8) fitness test events were: $R^2 = 0.835$; $p \leq 0.05$ (see Table 20)[10].

Reliability of Physical Assessments

An important aspect of physical performance assessment is the repeatability of the measures over time, i.e., inter-rater reliability. During the Sequential Validation analysis at FT Benning, Soldiers (n = 152) were administered the eight physical fitness test events sequentially with no programmed rest on Monday and again on Thursday. The predictor tests were administered over a 90-minute period each day at the same time/location, in the same order, using the same testing procedures and graders. The Cronbach's alpha values by test event are presented in Table 21. The lowest value was for the Sled Push = 0.839 and the highest repeatability value was for the Power Throw = 0.991. All the Cronbach's alpha statistics exceeded the .70 criterion level "rule of thumb" for acceptable reliability (Tavakol and Dennick, 2011).

CONCLUSIONS

In the present study (HQDA EXORD 041-13), USACIMT was tasked to answer three questions: (1) what are the baseline physical readiness requirements of the physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills and Common Soldier Tasks; (2) does the current 3-event Army Physical Fitness Test (APFT) adequately assess the baseline physical readiness requirements required to execute WTBD/CSTs; and (3) if the 3-event APFT is insufficient to assess the baseline physical requirements, what physical fitness test events better predict a Soldier's success on high physical demand WTBD/CSTs? Based on the findings of this study, the answers to these three questions are:

1. The baseline physical components required for Soldier success on high-demand Warrior Tasks and Battle Drills and Common Soldier Tasks are: muscular strength, anaerobic power, aerobic and anaerobic endurance, and muscular endurance. Training in, and assessment of, these primary components of physical fitness are necessary to prepare Soldiers to overmatch in multi-domain operations. Additional focus on the skill-related

[10] This full regression model for all eight (8) fitness test events utilized an average of ACFT scores from Day1 and Day2. When analyzed independently, the $R^2_{Day1} = 0.806$ and $R^2_{Day2} = 0.788$.

components of fitness such as flexibility, balance, agility and coordination will further enhance the quality of movement.

2. The Army Physical Fitness Test (APFT) is a relatively low-to-moderate predictor of WTBD/CSTs performance ($R^2 = 0.423$): $p \leq 0.05$ demonstrating the APFT is insufficient to ensure Soldiers are capable of performing physically demanding, commonly occurring, and critical Warrior Tasks and Battle Drills and Common Soldier tasks.
3. The eight (8) test event battery identified in the Baseline Soldier Physical Readiness Requirements Study is a relatively high predictor of WTBD/CSTs performance ($R^2 = 0.835$); $p \leq 0.00$.

To ensure Soldiers are prepared to execute physically demanding combat tasks, individual and unit physical fitness programs must train and assess all components of fitness. Test events measuring muscular strength, aerobic and anaerobic endurance, and anaerobic power were most predictive of combat task performance, although secondary measures of speed, core strength, and upper body muscular endurance accounted for additional predictive variability. The secondary measures also provide physiological balance to the test battery and address components of fitness most likely to mitigate significant musculoskeletal injuries. In addition, factors related to balance, agility, flexibility and coordination were intrinsic to the primary and secondary assessments.

RECOMMENDATIONS

• The Army can significantly improve predictive power for combat task performance by including fitness test events that assess muscular strength, anaerobic endurance and explosive power.

• There are additional test events (push press, leg tuck/heel hooks, and 300yd shuttle run) that can add significantly to combat task performance and have the potential to reduce MSK-Is through more comprehensive physical fitness training.

• While the eight (8) fitness test events identified in this study require some equipment, this equipment is incredibly durable, which reduces overall costs. The potential to reduce injuries through more focused and progressive physical readiness training may further reduce testing costs through cost recovery.

• The Army has not changed the record physical fitness test for the last 40 years. Any changes to the record test must be approached slowly, allowing Soldiers time adapt to new training and testing requirements.

POST HOC ANALYSIS:

In the year following the conclusion of the Baseline Soldier Physical Readiness Requirements Study, Army senior leaders engaged in numerous discussion pertaining to changes to the doctrinal “test of record” for the Army. There were three primary concerns: (1) administration time, (2) equipment costs, and (3) number of test events. The Baseline Soldier Physical Readiness Requirements Study team was asked to resolve these three concerns.

As a result, the team recommended consolidating three of the eight test events into a single test event to reduce the total number of test events from eight to six. The logical events to consolidate were the measures of anaerobic power and anaerobic endurance. Researchers combined portions of the sled drag, sled push, and 300yd shuttle run to form the 250m Sprint-Drag-Carry (SDC) test event. The SDC is comprised of: 50m sprint, 50m sled drag, 50m sprint[11], 50m farmers carry, 50m sprint. In an attempt to understand how this consolidated variable might affect the overall explained variance in the full model regression, researchers computed a composite variable based on the standardized values of the sled push, sled drag, and 300yd shuttle run. The six (6) test event battery develop using the composite SDC event and the leg tuck, computed from the FT Benning data, remains a relatively high predictor of WTBD/CSTs performance; $R^2 = 0.795$; $p \leq 0.05$ (see Table 22).

[11] The second 50m sprint was later changed to a 50m lateral.

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TABLES

Table 1. Components of Physical Fitness

Domain	Generic Term	Factor Analytic Approach	Human Ability Approach	Physical Measure
Physical / Health-related Fitness	Muscular Strength	Static Strength Dynamic Strength	Static Strength Explosive Strength	Maximal Force Maximal Power
	Muscular Endurance	Muscular Endurance Trunk Endurance	Dynamic Strength Trunk Strength	Short-term sustained force or average power
	Cardiovascular Endurance	Aerobic Endurance	Stamina	Speed/distance or long-term sustained force/power
	Flexibility	Plasticity Elasticity	Extent Flexibility Dynamic Flexibility	Distance (range of motion)
	Body Composition	Body Weight Fat Mass Lean Mass	Body Fat	Mass (body tissue amount)
Motor / Skill-related Fitness	Agility	Change of Direction		Shuttle sprints
	Coordination	Summation of body parts during movement		Ball-handling skills Obstacle course
	Power	Explosive Power Anaerobic Power	Expressed as force / time	Jumps and Throws
	Speed	Anaerobic Endurance		Linear Sprints
	Balance	Static Balance Dynamic Balance Stability		Stationary one-leg stand Beam walks

SOURCE: USACHPPM 2004

Table 2: BSPRRS Samples by Installation.

n	FT Jackson	FT Carson	3/75 Rangers	FT Riley	FT Benning	Total
Men	19	224	34	278	136	691
Women	7	40	n/a	46	16	109
Total	26	264	34	324	152	800

1. Assessing face validity: content development sample – FT Jackson, SC – 26
2. Assessing content validity: content validation sample – FT Carson, CO – 264
3. Assessing external responsiveness: external relevance sample – FT Benning, GA – 34
4. Assessing predictive validity: predictor variable sample – FT Riley, KS – 324
5. Assessing sequential validity: sequential validation sample – FT Benning, KS – 152

Table 3. 23 Common Physical Fitness Test Events with Testing Descriptions

	Event	Equipment	Description
1	Standing Long Jump	Tape measure, flat surface	From a standing position behind the restraining line, swing your arms and jump as far as possible, landing in a balanced, upright position on both feet. Distance was scored from the back of the heel nearest to the start line. Faults were not scores. There were three trials.
2	Vertical Jump	VERTEC Jump, flat surface	From a standing position, swing your arms and jump as high as possible, landing in a balanced, upright position on both feet. Strike the highest plastic tab with your dominant hand. Soldier may not stutter-step or hop before jumping. There were three trials.
3	Medicine Ball Throw	20lb Medicine Ball, flat surface	With your back to the restraining line flex at the knees, hips, waist to lower the ball into a "squat position"; explosively extend at the knees-hips-waist swinging the arms/ball upward over your head and heave the 20lb medicine ball as far as possible; finish the movement in a balanced, upright position with both feet behind the restraining line.
4	Sled Push	125lb prowler sled; flat surface	From a standing, forward-leaning position behind the prowler sled grasp the upright poles; with arms extended and using the legs, push the 125 loaded sled for 25m down and 25m back to the start line.
5	Sled Drag	4x40-lb sandbag sled; flat surface	From a standing, rear-leaning position behind the restraining line cradling a 40lb sandbag in your arms; grasp the hand loops to the pull strap and pull 4-40lb sandbags 25m down and 25m back to the start line.
6	Sumo Squat (see FM 7-22)	80lb Kettlebell; flat surface	With the trunk basically upright, flex at the hips/knees until the thighs are perpendicular to the surface; grasp the 80lb kettlebell in both hands; extend the hips/ knees until upright; repeat until volitional fatigue. (subjects were allowed to use a lighter weight if they couldn't execute 1 repetition with the 80lb kettlebell)
7	Bench Press Strength	44lb Olympic Bar, 110lbs weight plates, spring collars, flat bench	Start in a supine position on a flat bench with five-points of contact; spotter will lift barbell (154lbs) to supported position/arm extended; subject will flex/extend the elbow/shoulder to lower and raise the bar; bar must touch chest and arms must go to full extension; repeat until volitional fatigue. (subjects were allowed to use a lighter weight if they couldn't execute 1 repetition with the 154lb barbell)
8	Hex-bar Deadlift	46 lb Hex bar; 125 lbs of weight plates; spring collars; flat surface	Start in a bent-knee squat position with the upper body basically upright; grasp the hex bar (171lbs) handles; lift and extend the legs until upright, repeat until volitional fatigue. (subjects were allowed to use a lighter weight if they couldn't execute 1 repetition with the 171lb hex bar)
9	dips	Dip bars	Start in a straight- arm supported position, arms fully extended; flex at the elbow/shoulder until the upper arm is 90^{o} to the lower arm; extend at the elbow to full extension; repeat until volitional fatigue.
10	Pull-ups	Pull-up Bars	Start in a straight-arm dead-hang position – palms away; flex the elbows/shoulder until the chin goes over the bar; keep the body generally straight; you may not swing or kip; repeat until volitional fatigue
11	Bench Press Endurance	Flat Bench, 44lb Olympic bar, 2x10lb weight plates	Start in a supine position on a flat bench with five-points of contact; spotter will lift barbell (64lbs) to supported position/arms fully extended; flex and extend at the elbow/shoulder to lower and raise the bar; bar must touch chest and arms must be fully extended; repeat until volitional fatigue.

12	Modified sit-ups (crunch)	Flat surface	Start in a supine position (shoulder blades touching the ground), knees bent (app. 90°) with arms crossed, fingers extended and touching the shoulder, flex at the trunk until the elbows touch the front of the knees; finger tips must stay in contact with the shoulders at all times; repeat until volitional fatigue
13	Leg Tuck (see FM 7-22)	Pull-up bar	Start in a straight-arm fully extended position with an opposing grip; flex the hips/knees/trunk until the knees (front of the thighs) touch the elbows; return to full extension; repeat until volitional fatigue
14	Weighted Trunk Rotations	Flat surface	Start in a "V" sit position with the knees bent (app. 90°); grasp the 20lb medicine ball; rotate the arms-trunk-upper body from side to side touching the ground with the medicine ball on each side/rotation; repeat until volitional fatigue
15	Abdominal rower (see FM 7-22)	Flat surface	Start in a supine position (shoulder blades touching the ground), legs straight with arms fully extended over the head; fingers touching the ground; flex the shoulders and waist to lift the upper body off the ground and move the arms forward; flex the hips/knees to bring the heels up to the buttocks; extend at the knees, hips, trunk, arms until the legs and arms are fully extended; repeat until volitional fatigue
16	Kettlebell Squat Endurance	40lb Kettlebells, flat surface	Grasp a 40lb kettlebell in both hands and cradle upside down (goblet squat) under the chin; with the trunk basically upright, flex at the hips/knees until the thighs are perpendicular to the surface; extend at the hips/knees until upright; repeat until volitional fatigue
17	300m shuttle run	25m lane, flat surface	On the command "go" run 25m to the opposite end of the lane; turn by placing at least one foot/hand on or over the line, return to the starting line; continue back and forth for six round trips (300m).
18	Loaded 300m Shuttle Run	25m lane, flat surface	Wearing a 26lb load, On the command "go" run 25m to the opposite end of the lane; turn by placing at least one foot/hand on or over the line, return to the starting line; continue back and forth for six round trips (300m).
19	Illinois Shuttle Test	Traffic cones, flat surface	On the command "go" - sprint around the cones on the agility course with many changes of direction as fast as possible. There are 2 trials.
20	400yd sprint	400yd flat surface - oval track	On the command "go" – sprint 400yd as fast as possible.
21	Push-up (see FM 7-22)	Flat surface	From the prone position, front leaning rest position (up position), lower the body until the arms reach 90°; extend at the elbows / shoulders until the arms are fully extended; repeat repetitions for 2-minutes.
22	Sit-up (see FM 7-22)	Flat surface	From the supine position, front leaning rest position (up position), lower the body until the arms reach 90°; extend at the elbows / shoulders until the arms are fully extended; repeat repetitions for 2-minutes.
23	2-mile Run (see FM 7-22)	Flat surface, < 3% grade	Run 2 miles are the fastest pace.

Table 4. Combat Loads for the WTBD-ST

Modified "Fighting Load"	Weight (lbs.)
Army Combat Uniform	12.00
Body Armor	23.15
M4 Carbine	7.50
Camelback With Water	3.50
Fighting Load Carrier and Accessories	1.20
Advanced Combat Helmet	3.25
Maximum Total Weight*	**50.60**

Modified "Sustainment Load"*	Weight (lbs.)
Army Combat Uniform	12.00
Body Armor	23.15
M4 Carbine w/magazine	11.78
Camelback With Water	7.10
Ammunition	6.42
Fighting Load Carrier and Accessories	1.20
Advanced Combat Helmet	3.25
Maximum Total Weight*	**64.90**

***Maximum Total Weight varied by Soldier depending on uniform, boot and body armor size.**

Table 5. Combined Top Ranked (1-3) Tasks (most physically demanding)

WTBD-ST Sub-Tasks	Day 1 ACU Only	Day 2 Fighting Load	Day 3 Pre-fatigue*
Prepare Fighting Position (bucket fill and sandbag stack)	**17%**	**16%**	**29%**
Move Over–Under- Around- Through (sprint, crawl, beam walk & carry; obstacle/wall series)	**4%**	**14%**	**12%**
Perform Combatives (tire flip, sandbag throw, SKEDCO pull, barrel rotation)	**52%**	**53%**	**34%**
Casualty Rescue (extricate and drag casualty)	**26%**	**23%**	**17%**
Road March (1600m loaded run/walk – 55-65 pounds)	**--**	**--**	**3 %**

* 10K ruck march with modified sustainment load followed by the WTBD-ST in fighting load

Table 6. WTBD-ST Time by ACU Only, Fighting Load, Pre-fatigue (Men)

WTBD-ST Condition	Group	N	Mean*	SD*	F	Sig
ACU Only	3/75+	34	6:59	0:48	5.569	0.019
	FRKS+	278	9:12	1:14		
Fighting Load	3/75	34	7:46	1:07	6.612	0.011
	FRKS	259	11:41	1:45		
Pre-Fatigue^	3/75	34	8:56	1:09	11.146	0.001
	FRKS	278	13:40	2:10		

* time measured in minutes/seconds

+ 3/75 – 3rd Battalion / 75th Ranger Regiment; FRKS – Fort Riley Kansas

^ WTBD-ST time in fighting load following the pre-fatigue in sustainment load

Table 7. Descriptive Statistic Comparisons for Males (WTBD-ST - Fighting Load)

	N	Mean	SD	Std. Error	95% CI		Min	Max
					Lower Bound	Upper Bound		
3/75 (1)	34	7:46	1:08	0:11	7:22	8:09	5:15	9:52
FT Benning (2)	136	9:58	1:30	0:07	9:43	10:14	6:28	16:40
FT Riley (3)	278	11:41	1:45	0:06	11:29	11:54	8:31	19:41
FT Carson (4)	259	14:28	4:15	0:15	13:56	14:59	7:57	32:12
Total	705	12:11	3:29	0:08	11:59	12:48	5:15	32:12

Table 8. ANOVA Statistic – Males (WTBD-ST - Fighting Load)

	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	2743.843	3	914.423	109.609	0.000
Within Groups	5864.843	703	8.343		
Total	8608.113	706			

3rd Battalion / 75th Ranger Regiment (1), FT Benning (2), FT Riley (3), FT Carson (4)

Table 9. Post Hoc Multiple Comparisons (Tukey) WTBD-ST (fighting load)

					95% Confidence Interval	
Males		Mean Difference	Std. Error	Sig.	Lower Bound	Upper Bound
3-75 (1)	2.00	2:12*	0:33	0.000	0:46	0:46
	3.00	3:55*	0:31	0.000	2:33	2:33
	4.00	6:41*	0:31	0.000	5:20	5:20
Benning (2)	1.00	2:12*	0:33	0.000	3:38	3:38
	3.00	1:42*	0:18	0.000	0:55	0:55
	4.00	4:29*	0:18	0.000	3:42	3:42
Riley (3)	1.00	3:55*	0:31	0.000	5:16	5:16
	2.00	1:42*	0:18	0.000	2:29	2:29
	4.00	2:46*	0:14	0.000	2:08	2:08
Carson (4)	1.00	6:41*	0:31	0.000	8:03	8:03
	2.00	4:29*	0:18	0.000	5:16	5:16
	3.00	2:46*	0:14	0.000	3:25	3:25

* The mean difference is significant at the 0.05 level.

Table 10. Age, Height, Weight (FT Riley)

		Age			Height			Weight		
		M	F	C	M	F	C	M	F	C
N		290	49	339	289	49	338	289	49	338
Mean		24	23	24	70	65	70	179	142	174
SD		4.5	3.0	4.4	2.5	3.0	3.2	25.2	21.9	27.9
Minimum		18	18	18	64	60	60	123	105	105
Percentiles	5	16	18	17	66	60	64	138	106	128
	10	18	19	18	67	61	66	147	114	138
	25	21	21	21	69	63	68	162	128	155
	50	24	23	24	70	65	70	179	142	174
	75	27	25	27	72	67	72	196	157	193
	90	30	27	29	74	69	74	212	170	210
	95	31	28	31	75	70	75	221	178	220
Maximum		44	30	44	77	72	77	257	205	257

Age = years; Height = inches; Weight = pounds

Table 11. Descriptive Statistics - Performance Times – WTBD-ST Vignettes (FT Riley)

ACU/Boots		Hasty Fighting Position (minutes)			Move OUAT (minutes)			Combatives (minutes)			Casualty Evacuation (minutes)			Total Field Vignettes (minutes)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		285	47	332	285	47	332	285	46	331	285	46	331	285	46	322
Mean		4:29	6:35	4:47	1:30	2:20	1:37	1:46	3:23	2:00	1:03	2:07	1:12	9:14	14:55	10:01
SD		0:37	1:20	1:03	0:13	0:29	0:24	0:23	1:07	0:46	0:25	0:59	0:39	1:16	3:09	2:34
Minimum		6:45	11:05	11:05	2:11	4:03	4:03	4:37	7:04	7:04	3:34	5:35	5:35	14:20	23:07	23:07
Percentile	5	5:30	8:47	6:30	1:51	3:07	2:16	2:23	5:13	3:15	1:44	3:44	2:16	11:19	20:06	14:15
	10	5:16	8:17	6:07	1:46	2:57	2:07	2:15	4:48	2:58	1:35	3:22	2:01	10:51	18:56	13:18
	25	4:53	7:28	5:29	1:38	2:39	1:53	2:01	4:08	2:31	1:19	2:46	1:38	10:05	17:02	11:44
	50	4:29	6:35	4:47	1:30	2:20	1:37	1:46	3:23	2:00	1:03	2:07	1:12	9:14	14:55	10:01
	75	4:04	5:41	4:04	1:21	2:00	1:20	1:30	2:37	1:29	0:46	1:27	0:45	8:22	12:47	8:17
	90	3:41	4:52	3:26	1:13	1:42	1:06	1:16	1:57	1:01	0:31	0:51	0:22	7:36	10:53	6:43
	95	3:27	4:23	3:03	1:08	1:32	0:57	1:08	1:32	0:44	0:21	0:29	0:07	7:08	9:43	5:46
Maximum		3:06	3:06	3:06	3:06	3:06	1:02	3:06	3:06	1:02	3:06	3:06	0:26	3:06	3:06	6:16

Fighting Load		Hasty Fighting Position (minutes)			Move OUAT (minutes)			Combatives (minutes)			Casualty Evacuation (minutes)			Total Field Vignettes (minutes)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		278	44	322	277	43	320	277	43	320	277	43	320	277	44	320
Mean		5:23	8:06	5:54	2:16	4:13	2:31	2:10	4:13	2:26	1:23	2:47	1:34	12:31	19:10	13:26
SD		0:37	1:23	1:17	0:25	0:59	0:51	0:27	1:19	0:57	0:35	1:08	0:50	3:07	4:06	3:59
Minimum		9:21	11:32	11:32	4:09	6:52	6:52	5:03	7:45	7:45	5:00	5:28	5:28	26:46	27:50	27:50
Percentile	5	6:24	10:22	8:01	2:57	5:50	3:55	2:54	6:23	4:00	2:20	4:39	2:56	17:39	25:55	20:00
	10	6:10	9:52	7:32	2:48	5:28	3:36	2:44	5:54	3:38	2:07	4:14	2:38	16:30	24:25	18:31
	25	5:47	9:01	6:45	2:32	4:52	3:05	2:28	5:06	3:04	1:46	3:32	2:07	14:37	21:55	16:07
	50	5:23	8:06	5:54	2:16	4:13	2:31	2:10	4:13	2:26	1:23	2:47	1:34	12:31	19:10	13:26
	75	4:58	7:10	5:02	1:59	3:33	1:56	1:51	3:19	1:47	0:59	2:01	1:00	10:24	16:24	10:44
	90	4:35	6:19	4:15	1:44	2:57	1:25	1:35	2:31	1:13	0:38	1:19	0:30	8:31	13:55	8:20
	95	4:21	5:49	3:46	1:34	2:35	1:06	1:25	2:02	0:51	0:25	0:54	0:11	7:22	12:24	6:51
Maximum		3:34	5:40	3:34	1:29	2:36	1:29	1:08	2:23	1:08	0:41	0:44	0:41	8:31	12:50	8:31

Pre-fatigue, Fighting Load		Hasty Fighting Position (minutes)			Move OUAT (minutes)			Combatives (minutes)			Casualty Evacuation (minutes)			Total Field Vignettes (minutes)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		258	35	293	256	35	292	256	35	291	258	35	293	256	35	291
Mean		6:13	9:05	6:34	2:41	4:23	2:54	2:39	4:29	2:53	1:33	3:25	1:46	13:41	22:10	14:42
SD		0:59	1:51	1:27	0:37	1:10	0:54	0:37	1:14	0:56	0:38	1:52	1:03	2:12	4:58	3:50
Minimum		9:07	13:44	13:44	8:49	7:43	8:49	5:38	7:07	7:07	6:24	8:36	8:36	21:38	34:47	34:37
Percentile	5	6:24	10:22	8:01	2:57	5:50	3:55	2:54	6:23	4:00	2:20	4:39	2:56	17:39	1:55	20:00
	10	6:10	9:52	7:32	2:48	5:28	3:36	2:44	5:54	3:38	2:07	4:14	2:38	16:30	0:24	18:31
	25	5:47	9:01	6:45	2:32	4:52	3:05	2:28	5:06	3:04	1:46	3:32	2:07	14:37	21:55	16:07
	50	5:23	8:06	5:54	2:16	4:13	2:31	2:10	4:13	2:26	1:23	2:47	1:34	12:31	19:10	13:26
	75	4:58	7:10	5:02	1:59	3:33	1:56	1:51	3:19	1:47	0:59	2:01	1:00	10:24	16:24	10:44
	90	4:35	6:19	4:15	1:44	2:57	1:25	1:35	2:31	1:13	0:38	1:19	0:30	8:31	13:55	8:20
	95	4:21	5:49	3:46	1:34	2:35	1:06	1:25	2:02	0:51	0:25	0:54	0:11	7:22	12:24	6:51
Maximum		3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34	3:34

Table 12. Descriptive Statistics -- Average Performance Repetitions, Times, Weights for the 23 Physical Fitness Field Test Events (FT Riley)

		25m Sled Push (sec)			25m Sled Drag (sec)			Standing Power Throw (ft)			Standing Long Jump (in)			Standing Vertical Jump (in)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		278	46	324	278	46	324	278	46	324	278	46	324	278	46	324
Mean		8.20	12.62	8.82	15.90	33.07	18.34	19.64	10.39	18.32	82.47	64.30	0.05	21.68	14.54	20.54
SD		1.55	2.30	2.28	3.70	11.47	8.13	3.92	2.74	4.97	10.43	7.59	0.03	4.82	2.81	4.47
Minimum		20.65	17.48	20.65	45.78	66.24	66.24	9.42	5.92	16.83	45.00	48.00	45.00	12.00	10.00	10.00
Percentiles	5	10.76	16.42	12.58	22.00	52.00	31.75	13.16	5.87	10.12	65.26	51.79	0.01	13.72	9.91	13.16
	10	10.18	15.57	11.74	20.64	47.75	28.74	14.61	6.88	11.96	69.12	54.59	0.02	15.50	10.95	14.82
	25	9.24	14.17	10.36	18.39	40.80	23.82	16.99	8.54	14.97	75.44	59.19	0.03	18.43	12.65	17.53
	50	8.20	12.62	8.82	15.90	33.07	18.34	19.64	10.39	18.32	82.47	64.30	0.05	21.68	14.54	20.54
	75	7.15	11.07	7.29	13.40	25.34	12.85	22.28	12.23	21.67	89.50	69.42	0.07	24.93	16.44	23.55
	90	6.21	9.67	5.91	11.16	18.39	7.93	24.66	13.89	24.68	95.82	74.01	0.08	27.85	18.14	26.26
	95	5.64	8.82	5.06	9.79	14.15	4.92	26.11	14.90	26.52	99.68	76.82	0.09	29.63	19.18	27.92
Maximum		5.63	9.00	5.63	8.85	15.59	8.85	35.33	16.83	35.33	108.00	80.00	108.00	35.00	21.00	35.00

		Illinois Shuttle (secs)			400M (min)			300yd Shuttle (sec)			Loaded Shuttle Run (min)			Goblet Squat (reps)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		278	46	324	278	46	324	278	46	324	278	46	324	278	46	324
Mean		19.34	21.51	19.65	1:15	1:33	1:17	67.76	77.99	69.22	1:16	1:32	1:19	32.19	17.87	30.15
SD		1.28	1.32	1.49	0:12	0:16	0:14	4.23	6.32	5.81	0:05	0:07	0:08	11.84	7.30	12.36
Minimum		24.72	25.69	25.69	2:10	2:22	2:22	86.00	97.43	97.43	1:39	1:54	1:54	7.00	8.00	7.00
Percentiles	5	21.45	23.69	22.11	1:34	1:59	1:40	74.75	88.42	78.80	1:24	1:43	1:32	13.72	9.91	13.16
	10	20.97	23.20	21.55	1:30	1:53	1:34	73.18	86.08	76.65	1:22	1:40	1:29	15.50	10.95	14.82
	25	20.20	22.40	20.65	1:23	1:43	1:26	70.62	82.25	73.13	1:19	1:36	1:24	18.43	12.65	17.53
	50	19.34	21.51	19.65	1:15	1:33	1:17	67.76	77.99	69.22	1:16	1:32	1:19	21.68	14.54	20.54
	75	18.47	20.62	18.64	1:06	1:22	1:07	64.91	73.73	65.30	1:12	1:27	1:13	24.93	16.44	23.55
	90	17.70	19.82	17.74	0:59	1:12	0:59	62.35	69.90	61.79	1:09	1:23	1:08	27.85	18.14	26.26
	95	17.23	19.33	17.18	0:55	1:06	0:53	60.78	67.56	59.64	1:07	1:20	1:05	29.63	19.18	27.92
Maximum		14.38	19.03	14.38	0:57	1:13	0:57	59.16	67.00	59.16	1:04	1:19	1:04	80.00	35.00	80.00

		Abdominal Rower (reps)			Modified Sit-ups (reps)			Trunk Rotation (reps)			Leg Tuck (reps)			Dips (reps)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		278	46	324	278	46	324	278	46	324	278	46	324	278	46	324
Mean		52.39	47.72	51.73	56.30	55.54	56.19	78.46	50.52	74.49	7.99	1.33	7.04	18.94	3.96	16.81
SD		30.59	31.56	29.13	34.09	19.78	33.03	48.44	43.18	48.66	4.67	1.85	4.96	8.79	17.69	9.79
Minimum		10.00	22.00	10.00	10.00	25.00	10.00	10.00	17.00	10.00	0.00	0.00	0.00	1.00	0.00	0.00
Percentiles	5	1.92	0.00	3.66	0.05	22.90	1.69	0.00	0.00	0.00	0.29	0.00	0.00	4.43	0.00	0.66
	10	13.24	7.32	14.44	12.67	30.22	13.91	16.46	0.00	12.21	2.01	0.00	0.70	7.68	0.00	4.28
	25	31.77	26.44	32.09	33.33	42.21	33.93	45.81	21.42	41.70	4.84	0.08	3.70	13.01	0.00	10.21
	50	52.39	47.72	51.73	56.30	55.54	56.19	78.46	50.52	74.49	7.99	1.33	7.04	18.94	3.96	16.81
	75	73.00	68.99	71.36	79.28	68.88	78.46	111.11	79.63	107.29	11.14	2.57	10.39	24.86	15.88	23.41
	90	91.54	88.12	89.01	99.94	80.86	98.48	140.47	105.80	136.78	13.96	3.69	13.39	30.19	26.60	29.34
	95	102.86	99.80	99.79	112.55	88.18	110.70	158.39	121.77	154.78	15.69	4.38	15.23	33.44	33.14	32.96
Maximum		211.00	111.00	211.00	250.00	130.00	250.00	400.00	300.00	400.00	24.00	7.00	24.00	50.00	16.00	50.00

		~1RM Deadlift (lbs)			~1RM Bench Press (lbs)			Pull-ups (reps)			Bench Press End (reps)			Sumo Squat (reps)		
		M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
n		278	46	324	278	46	324	278	46	324	278	46	324	278	46	324
Mean		257.08	164.01	243.87	201.58	93.92	186.29	6.95	0.70	6.06	53.69	17.74	48.58	33.44	18.22	31.28
SD		32.11	26.05	45.62	41.27	19.78	54.15	4.07	1.15	4.38	18.97	9.37	21.88	13.34	9.10	13.87
Minimum		173.23	97.25	97.25	80.62	55.72	55.72	0.00	0.00	0.00	10.00	3.00	3.00	4.00	5.00	4.00
Percentiles	5	204.09	121.03	168.58	133.48	61.29	96.95	0.24	-1.21	-1.16	22.39	2.28	12.49	11.43	3.21	8.39
	10	215.98	130.67	185.47	148.75	68.61	116.99	1.75	-0.78	0.46	29.41	5.75	20.58	16.37	6.57	13.52
	25	235.44	146.45	213.11	173.76	80.59	149.80	4.21	-0.08	3.11	40.90	11.43	33.84	24.45	12.09	21.93
	50	257.08	164.01	243.87	201.58	93.92	186.29	6.95	0.70	6.06	53.69	17.74	48.58	33.44	18.22	31.28
	75	278.72	181.57	274.62	229.40	107.26	222.79	9.69	1.47	9.01	66.47	24.05	63.33	42.43	24.35	40.63
	90	298.18	197.35	302.26	254.41	119.24	255.60	12.15	2.17	11.66	77.96	29.73	76.59	50.52	29.86	49.04
	95	310.06	206.99	319.15	269.68	126.56	275.63	13.66	2.60	13.28	84.98	33.20	84.68	55.45	33.23	54.17
Maximum		341.55	230.42	341.55	292.24	147.12	292.24	20.00	4.00	20.00	141.00	40.00	141.00	100.00	50.00	100.00

		APFT PU (reps)			APFT SU (reps)			APFT 2MR (min)		
		M	F	C	M	F	C	M	F	C
n		278	46	324	278	46	324	278	46	324
Mean		66.40	41.41	62.85	69.63	67.59	69.34	14:27	16:37	14:45
SD		12.39	12.96	15.21	10.52	12.54	10.83	1:17	1:32	1:31
Minimum		39.00	20.00	20.00	40.00	45.00	40.00	20:41	20:30	20:41
Percentiles	5	45.95	20.03	37.75	52.28	46.89	51.47	16:34	19:08	17:15
	10	50.54	24.83	43.38	56.17	51.53	55.48	16:05	18:34	16:41
	25	58.05	32.68	52.60	62.54	59.13	62.04	15:18	17:39	15:46
	50	66.40	41.41	62.85	69.63	67.59	69.34	14:27	16:37	14:45
	75	74.76	50.15	73.11	76.72	76.04	76.64	13:35	15:35	13:43
	90	82.27	58.00	82.33	83.10	83.64	83.21	12:48	14:39	12:48
	95	86.85	62.79	87.96	86.99	88.29	87.21	12:19	14:05	12:14
Maximum		123	100	123	102	105	105	11:29	13:27	11:29

Table 13. Full Model Regression Coefficients for WTBD-ST (FT Riley)

Constant	Push-up	Sit-up	2-mile Run	R^2
329.559*	-7.187*	3.609*	.794*	.423

$p \leq 0.05$

Table 14. Stepwise Regression Coefficients for WTBD-ST (FT Riley)

Constant	Sled Drag	2-mile Run	~1RM Deadlift	Sled Push	Push-up	Kettlebell Squat	Power Throw	R^2
542.208*	10.035*	0.411*	-0.596*	12.292*	-1.453*	-1.452*	-4.737*	.737

$p \leq 0.05$

Table 15. Stepwise Regression Coefficients for WTBD-ST for Adjusted* Test Events (FT Riley)

Constant	Sled Drag	2-mile Run	Sled Push	1RM Deadlift	Push-up	Leg Tuck	300yd Shuttle	Power Throw	R^2
436.536*	9.666*	0.379*	12.915*	-0.789*	-0.979	-1.957	1.674	-4.385*	.735

* Adjustments made to ensure proper physiologic balance to include anaerobic endurance, core strength training.

$p \leq 0.05$

Table 16. Height, Weight (FT Benning)

		Height			Weight		
		M	F	C	M	F	C
N		136	16	152	136	16	152
Mean		70	65	69	180	138	176
SD		2.7	3.1	3.1	26.4	15.9	28.5
Minimum		62	60	60	120	110	110
Percentile	5	66	60	64	137	112	129
	10	67	61	65	146	118	140
	25	69	63	67	162	127	157
	50	70	65	69	180	138	176
	75	72	67	71	198	149	195
	90	74	69	73	214	158	212
	95	75	70	74	223	164	223
Maximum		76	70	76	233	164	233

Table 17. Descriptive Statistics -- Average Performance Repetitions, Times, Weights for the 8 Physical Fitness Field Test Events (FT Benning)

Day 1 - Monday		Power Throw	Sled Push	Leg Tuck	Sled Drag	300y Shuttle	Deadlift	Push-up	2-mile Run
N		152	152	152	152	152	152	152	152
Mean		20.58	32.55	8.88	67.02	1:10	225.20	51.95	17:10
SD		5.75	30.25	5.46	48.33	0:07	49.21	13.91	2:05
Minimum		6.67	248.25	0.00	458.38	12:43	96	20	24:09
Percentiles	5	11.10	82.47	0.00	146.76	1:22	144	29	20:37
	10	13.22	71.28	1.89	128.88	1:19	162	34	19:51
	25	16.71	52.94	5.20	99.59	1:15	192	43	18:35
	50	20.58	32.55	8.88	67.02	1:10	225	52	17:10
	75	24.46	12.16	12.56	34.44	1:06	258	61	15:45
	90	27.94	0.00	15.87	5.16	1:01	288	70	14:29
	95	30.07	0.00	17.89	0.00	0:59	306	75	13:42
Maximum		38.83	14.94	25.00	25.66	0:53	276	88	13:10
Day 2 - Thursday		**Power Throw**	**Sled Push**	**Leg Tuck**	**Sled Drag**	**300y Shuttle**	**Deadlift**	**Push-up**	**2-mile Run**
N		142	144	143	143	142	142	143	143
Mean		20.68	33.65	9.50	67.02	1:11	234.10	53.18	16:31
SD		5.72	23.59	6.06	48.33	0:06	42.92	14.62	1:59
Minimum		6.33	218.66	0.00	458.38	1:37	116	21	22:47
Percentiles	5	11.23	72.57	0.00	146.76	1:22	163	29	19:48
	10	13.35	63.84	1.74	128.88	1:19	179	34	19:04
	25	16.82	49.55	5.42	99.59	1:16	205	43	17:51
	50	20.68	33.65	9.50	67.02	1:11	234	53	16:31
	75	24.53	17.75	13.59	34.45	1:07	263	63	15:10
	90	28.00	3.46	17.26	5.16	1:04	289	72	13:58
	95	30.12	0.00	19.51	0.00	1:01	305	77	13:14
Maximum		38.33	14.37	29.00	22.01	0:58	276	96	12:27

Power Throw – feet
Sled Push and Sled Drag – seconds
Leg Tuck and Push-ups – repetitions
300y Shuttle and 2-mile Run – minutes seconds

Table 18. Descriptive Statistics - Performance Times – WTBD-ST Vignettes (FT Benning)

ACU/Boots		Fighting Position	Move OUAT	Combatives	Casualty	Total
N		152	152	152	152	152
Mean		4:10	1:33	1:50	1:17	9:09
SD		0:54	0:25	0:42	0:47	2:29
Minimum		10:17	4:54	6:06	7:33	0:32
Percentiles	5	5:40	2:15	3:00	2:36	13:16
	10	5:20	2:06	2:44	2:18	12:21
	25	4:47	1:50	2:19	1:49	10:50
	50	4:10	1:33	1:50	1:17	9:09
	75	3:33	1:16	1:21	0:45	7:28
	90	2:59	1:00	0:55	0:16	5:57
	95	2:39	0:51	0:40	0:00	5:02
Maximum		2:51	0:36	0:37	0:32	5:49
Fighting Load		**Fighting Position**	**Move OUAT**	**Combatives**	**Casualty**	**Total**
N		152	152	152	152	152
Mean		4:33	2:14	2:09	1:28	11:01
SD		1:20	1:00	1:05	1:07	4:14
Minimum		13:18	10:35	10:08	10:32	15:08
Percentiles	5	5:40	2:15	3:00	2:36	13:16
	10	5:20	2:06	2:44	2:18	12:21
	25	4:47	1:50	2:19	1:49	10:50
	50	4:10	1:33	1:50	1:17	9:09
	75	3:33	1:16	1:21	0:45	7:28
	90	2:59	1:00	0:55	0:16	5:57
	95	2:39	0:51	0:40	0:00	5:02
Maximum		2:11	1:10	1:00	0:34	6:28

Table 19. Stepwise Regression Coefficients for WTBD-ST (FT Benning)

Constant	Sled Drag	Power Throw	2-mile Run	1RM Deadlift	R^2
7.422*	0.057*	-0.090*	0.263*	-0.012*	.832

$p \leq 0.05$

Table 20. Full Model Regression Coefficients for WTBD-ST (FT Benning)

Constant	Sled Drag	2-mile Run	1RM Deadlift	Push-up	Leg Tuck	Power Throw	300y Shuttle	Sled Push	R^2
6.718*	0.049*	0.278*	-0.012*	-0.003	0.020	-0.099*	-0.266	0.016	.835

$p \leq 0.05$

Table 21: Cronbach's Alpha for Repeated Measures of Eight Test Events (FT Benning)

Test Event	Cronbach's Alpha
Power Throw	.991
Sled Push	.839
Leg Tuck	.906
Sled Drag	.908
300yd Shuttle Run	.819
Deadlift	.940
Push-up	.924
2-mile Run	.886

Table 22. Full Model Regression Coefficients for WTBD-ST* (FT Benning)

Constant	~S-D-C	2-mile Run	1RM Deadlift	Push-up	Leg Tuck	Power Throw	R^2
12.212*	1.203*	0.159	-0.015*	0.021	0.031	-0.082	.795

$p \leq 0.05$

*SDC (Sprint-Drag-Carry) is a composite score based on the sum of Z scores for the 300yd shuttle run, the sled push and sled drag.

Figure 1: Warrior Task and Battle Drill - Simulation Test Photos

Figure 2. Warrior Task and Battle Drill - Simulation Test Schematic

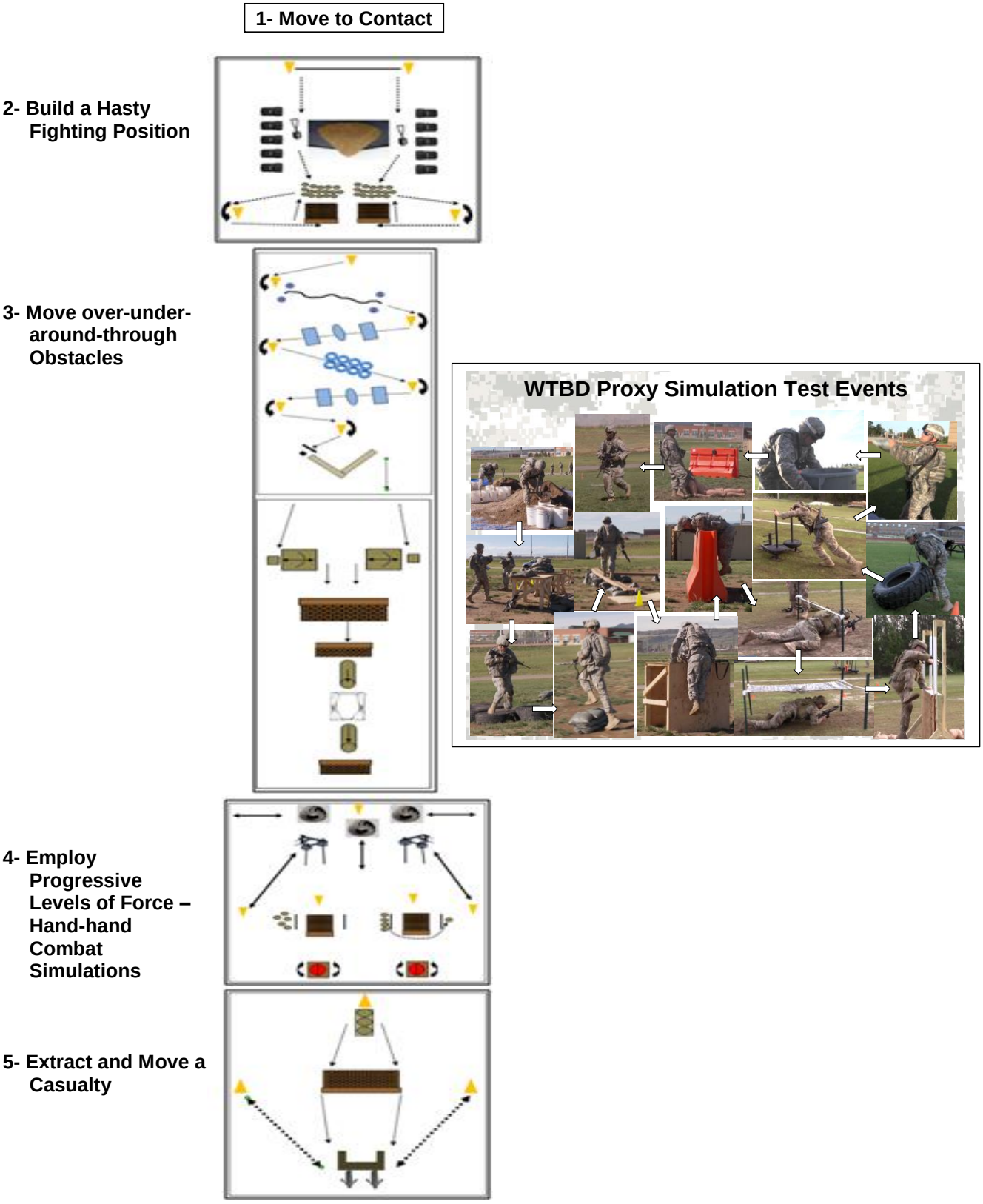
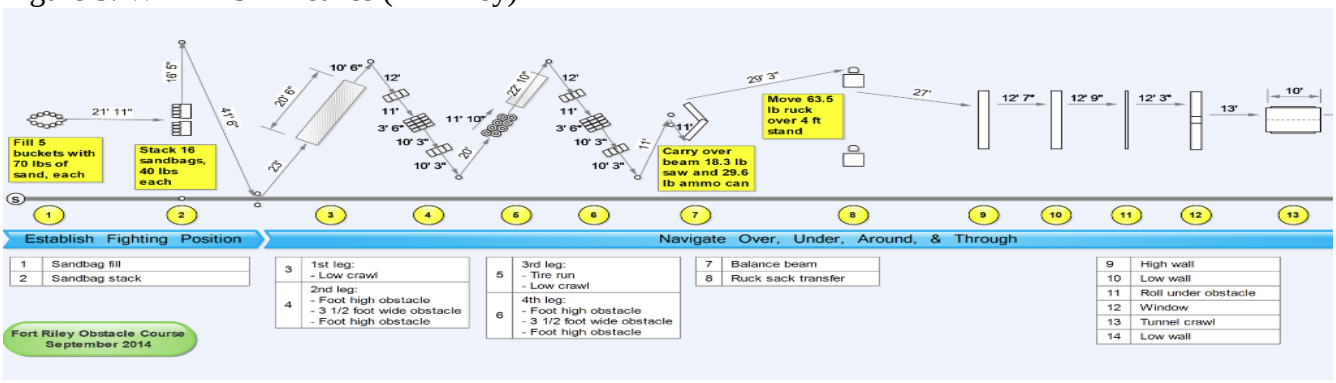


Figure 3. WTBD-ST Metrics (FT Riley)



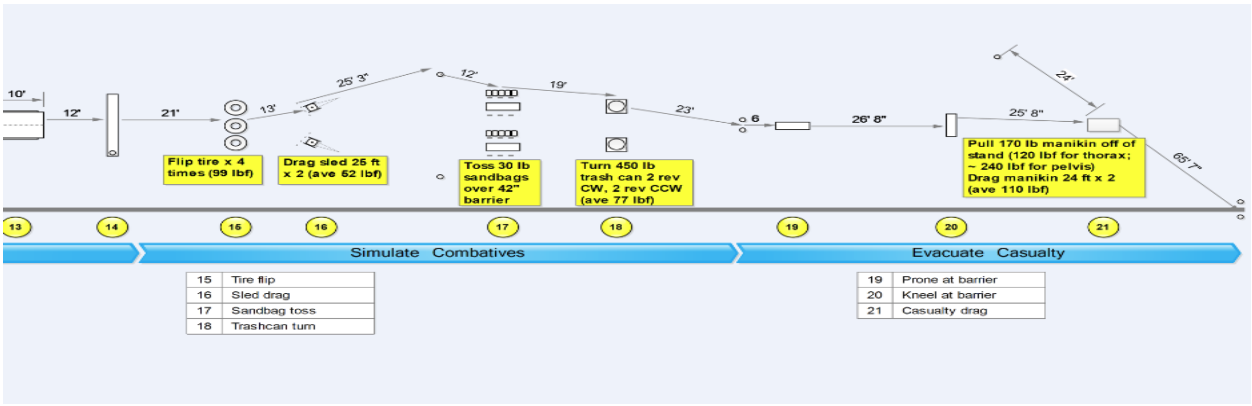
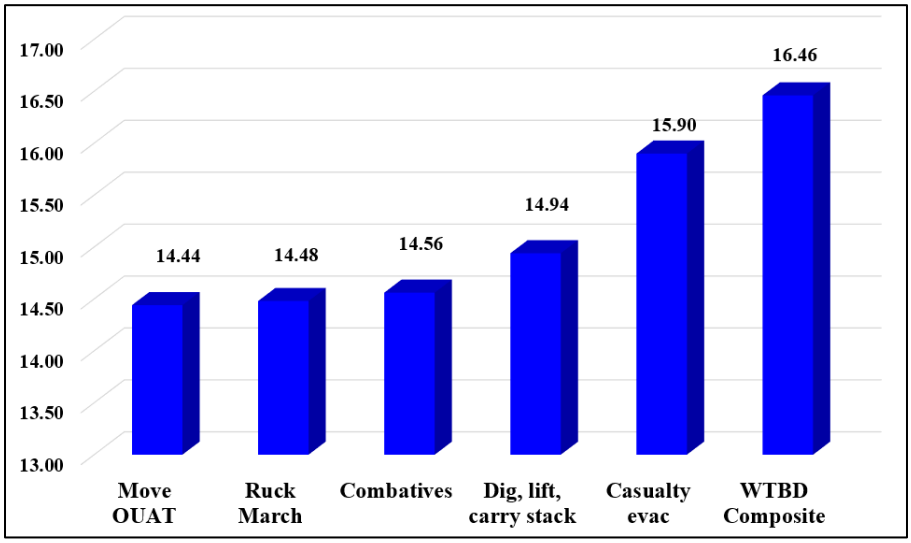
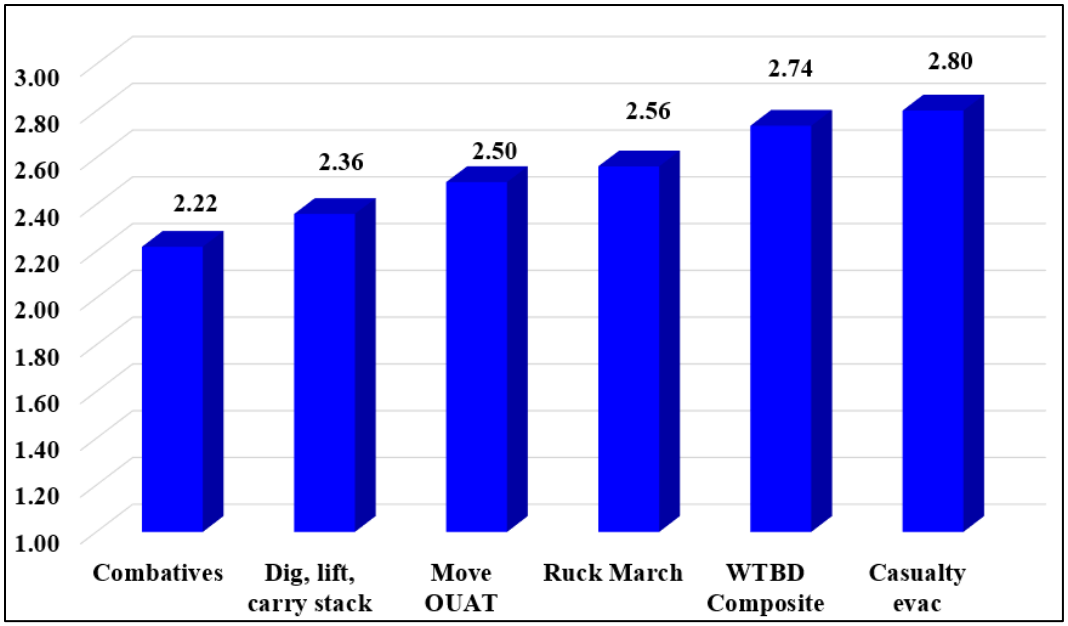


Figure 4. Rate of Perceived Exertion by WTBD-ST Event*



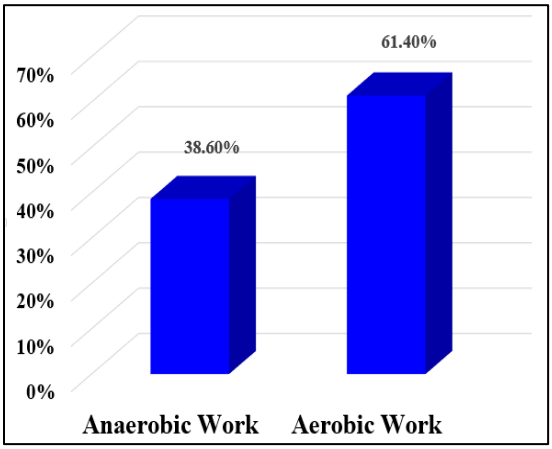
*RPE scale = 6-20

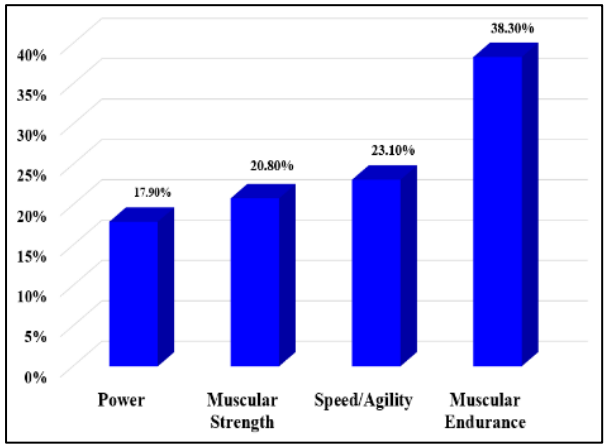
Figure 5 – Application of WTBD-ST Events to Combat Environment*



***Rating scale = 1-3**

Figure 6: Work Capacity Time on Task Analysis for WTBD-ST Events





APPENDIX A. High Physical Demand WTBD-ST Vignettes

1. Conduct a foot movement under load (movement to contact): The purpose of the foot movement under load was to simulate movement to an objective. The foot movement was designed to simulate the fatigue that occurs in movement to contact. Respondents at the FT Benning focus groups reported that most foot movements during actual military operations were 3000-5000m. After considering other Army ruck march tests (i.e., the air assault ruck-march test), a distance of 10k was selected to simulate foot movement under load. During the field observations at FT Jackson and FT Carson the 10k loaded ruck march was used (with a modified sustainment load = 55-65lbs). Upon analysis, moving 10k in a modified load at a self-directed pace did not differentially affect a Soldier's performance on the four field-based warrior task vignettes (fighting position, move O-U-A-T, react to man-man, and casualty evacuation); i.e., did not provide a sufficient pre-fatigue effect that was expected to occur in a movement to contact scenario. Also, the time constraints required to conduct a self-paced 10k march made it practically impossible to regulate the transition of Soldiers from the march to the field vignettes (Mean = 1:47:12). The bivariate correlations for the field-based vignettes between Day 3 (under load with no pre-fatigue) and Day 4 (following a 10k loaded foot march) were r = .837 (FT Carson). During Phase IV (criterion validation phase) of the study the loaded foot movement was changed to a 1600m loaded walk/run. This distance was field tested on a sample of Soldiers from the 3rd Battalion / 75th Ranger Regiment at FT Benning. Soldiers were instructed to move as quickly as possible. The average 1600m run times with a 55-65lb load was 09:37. The average HR (heart rate) was 177 bpm and the average RPE (rate of perceived exertion) was 15. The average 1600m run/walk time for the FT Riley sample was 12:22). These values ensure the 1600m run/walk provided a pre-fatigue load (as might be expected in a movement to contact) that meets or exceeds the pre-fatigue of the 10k loaded foot march. The bivariate correlation coefficient for the WTBD-ST scores for Day 3 (modified fighting load) and Day 4 (following the 1600m run/walk) was r = .831 (FT Riley), which directly coincides with the correlation coefficient obtained between WTBD-ST scores for Day 3 (modified fighting load) and Day 4 (following the 10k ruck march) for the FT Carson sample (.837).

2. Prepare a hasty fighting position (fighting position): Soldiers completed a dig/fill/carry/stack task designed to simulate building a hasty fighting position. Soldiers filled five 5-gal buckets with sand using an e-tool. Soldiers were required to keep the buckets flat on the ground, maintain two hands on the e-tool, and fill the bucket completely full (i.e., level across the top). Soldiers then moved 2m to a "pile" of sixteen 40lb sandbags piled randomly on the ground. They lifted as many sandbags as they could carry (generally one/two sandbags at a time), carried them 10m, and stacked them in 4x4 rows on top of a 32" platform. Once all 16 sandbags had been stacked, the Soldier ran 5m to the start of the move over/under/around/through obstacle (move OUAT).

3. Move Over/Under/Around/Through Obstacles (move OUAT). Soldiers completed the ~ 75m obstacle course that required them to sprint 15m, high crawl 10m, zigzag run 45m while jumping over four low obstacles (18"), two simulated ditch (48") and negotiating 8 tires; traverse a 24' v-shaped balance beam (both ends of the beam rested on the ground with the apex elevated 24" (Soldiers carried a 20-lb squad automatic weapon and a 20-lb ammo can);

sprint 10m and lift a 50lb ruck sack onto the 48" platform, climb onto the platform, move across the platform, lower themselves and the object to the ground; sprint 5m and scale a 54" wall; move over a 42" barrier, under an 18" barrier, through a window (the sill height was 42"), through a 24" x 5' "tunnel", over a 42" barrier and sprint 10m to the start of the combatives ("react to hand-hand contact") vignette. All these obstacles simulate commonly occurring obstacles in urban/forest terrains.

4. React to hand-hand contact (combatives): In the 2015 Soldier Survey, combatives was identified as the most physically demanding warrior task. The U.S. Army Combatives School, FT Benning, was tasked to determine a series of physical tasks that could be used as a proxy to assess the physical demands associated with hand-hand contact such as pushing, pulling, grasping, and throwing. They proposed four obstacles in the "combatives" simulation. Obstacle one was an LMTV tire flip (~ 107lbs); lying flat on the ground the Soldier completed four "tire flips"; sprint 5m to Obstacle two – the power push/drag; pushed/dragged a weighted sled/SKEDCO (~ 163lbs) 20m; sprinted 10m to Obstacle three – power throw; lifted/throw five 30-lb sandbags over the 54" wall from behind the 1m restraining line; sprinted 5m to Obstacle four – barrel turn; grabbed the handles of a 55-gal trashcan, resting on a 4x4 piece of plywood, filled with ~ 300lbs of sand and rotated the trashcan 2x360^{o} clockwise and 2x360^{o} counter-clockwise; sprinted 5m to the start of the casualty extraction/drag obstacle.

5. Casualty extraction and drag (casualty evacuation): Soldiers began the casualty evacuation task in a prone position beside a 6'x42" linear barrier. Soldiers stood up and completed a 5m 3-5 second rush to a second 42" horizontal barrier where they took a knee and looked around the side edge of the barrier. Soldiers stood up and completed a 5m crouch run to the objective – a "disabled HUMVEE" (4' x 6' plywood platform 47" high with a 2x2 wooden border). At the "disabled HUMVEE" the Soldier extracted a wounded Soldier off the platform (160lb training dummy with FLIC and plates; total weight ~ 182lbs) and lowered it to the ground. Once the casualty was on the ground the Soldier dragged the casualty 20m to safety and sprinted 5m to exit the WTBD-ST field course. To "break contact" Soldiers executed a final 60m sprint.