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The U.S. Army Research Institute of Environmental Medicine (USARIEM) was tasked by the U.S. Army Training and Doctrine Command (TRADOC) to develop criterion-based physical requirements for entry into the seven physically demanding combat MOSs, including the 12B Combat Engineers. Researchers from USARIEM completed three studies to develop a valid, safe, and legally defensible physical performance battery to predict a Soldier's ability to serve in the MOS. Study 1 involved measuring and identifying the physiological requirements of each of the tasks of the MOS in order to identify a set of criterion tasks encompassing the physical demands of all of the tasks of the MOS. Study 2 involved developing task simulations of the four most physically demanding tasks (casualty evacuation, casualty drag, sandbag carry, and foot march). In the final study, four test batteries were developed to fit a range of needs of the Army. Potential predictor tests included 300 m sprint, 2-min arm ergometer, beep test, medicine ball put, 1-min sit-up, 1-min push-up, standing long jump, and 38 cm upright pull.

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**USARIEM TECHNICAL REPORT T16-5**

# DEVELOPMENT OF A PHYSICAL EMPLOYMENT TESTING BATTERY FOR 12B COMBAT ENGINEERS

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## DISCLAIMERS

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## FOREWORD

This Technical Report is the first in a series documenting the development of a physical employment screening test for seven Combat Arms Military Occupational Specialties (MOSs) as part of the Soldier 2020 initiative. The models presented herein are developed specifically using information from the 12B studies and the models apply to only the 12B. Additional reports describe the subsequent studies and models developed for the Field Artillery (13B, 13F), Infantry (11B, 11C) and Armor (19D, 19K) MOSs. A final report will provide a single testing battery with acceptable predictive capability to identify candidates for each of the seven MOSs.

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| | |
|---|---|
| ACH | Advanced Combat Helmet |
| ACU | Army Combat Uniform |
| AIT | Advanced Individual Training |
| AOC | Area of Concentration |
| APFT | Army Physical Fitness Test |
| APOBS | Anti-Personnel Obstacle Breaching System |
| ASVAB | Armed Services Vocational Aptitude Battery |
| BCT | Basic Combat Training |
| BFV | Bradley Fighting Vehicle |
| EEOC | Equal Employment Opportunity Compliance |
| ESBI | Enhanced Side Ballistics Insert |
| ESAPI | Enhanced Small Arms Protective Insert |
| FMTV | Family of Medium Tactical Vehicles |
| HEI-T | High Explosive Incendiary Tracer |
| HR | Heart Rate |
| IOTV | Improved Outer Tactical Vest |
| MEPS | Military Entrance Processing Station |
| MOPMS | Modular-Pack Mine System |
| MOS | Military Occupational Specialty |
| OCOE | Office of the Chief of Engineer |
| OSUT | One Station Unit Training |
| PPE | Personal Protective Equipment |
| RPE | Rate of Perceived Exertion |
| SME | Subject Matter Expert |
| TRADOC | Training and Doctrine Command |
| USARIEM | U.S. Army Research Institute of Environmental Medicine |
| $VO_2$ | Oxygen Uptake |
| VTC | Video Teleconference |

## BACKGROUND

Performing physically demanding tasks is an integral part of being a Soldier (33). In general, these tasks include combinations of lifting/lowering, lifting and carrying, pushing/pulling, climbing, digging, and walking/marching/running. Such tasks require a great deal of muscular strength, muscular endurance, and cardiovascular fitness. While recruits in the U.S. Army are required to complete a mental aptitude test (Armed Services Vocational Aptitude Battery (ASVAB)) in order to enlist in certain Military Occupational Specialties (MOSs), Soldiers are not currently selected for their MOS based on their abilities to do the physical tasks necessary for that MOS. The safety and efficiency of Soldiers is based upon the ability of everyone in the team being capable of completing these physically demanding tasks. Thus, when assigning a Soldier to a MOS, it is important to match the physical capabilities of the Soldier with physical requirements of the critical tasks of that MOS. Otherwise, Soldiers who are physically unsuited to the MOS are at risk for injuring themselves and those around them and have the potential to diminish larger group performance. In addition, training time and resources are misused on individuals who are not physically capable of being trained to perform these demanding tasks.

Presently, the only way that the Army assesses a Soldier's physical readiness for occupational and combat-related duties is through the Army Physical Fitness Test (APFT). This test creates a score based on the number of push-ups performed in 2 min, number of sit-ups performed in 2 min, and time to complete a 2 mi run. A number of studies have shown, however, that this score is not highly correlated with the performance of the physically demanding tasks performed by Soldiers (15, 22). Furthermore, the APFT score includes adjustments for age and sex, not only biasing for/against certain groups, but making it potentially legally indefensible if used as a screening tool for entrance into certain MOSs (11). Using physically demanding tasks corresponding to an MOS as a screening assessment is not practical and may violate the EEOC Uniform Guidelines on Employment Selection Procedures (9178). However, criterion-based physical performance tests (i.e., tests that are predictive of Soldiering task performance) can be used to predict whether Soldiers possess the physical capabilities needed for effective MOS performance.

The U.S. Army Research Institute of Environmental Medicine (USARIEM) has been tasked by the Training and Doctrine Command (TRADOC) to develop a new criterion-based physical testing procedure for entry into seven physically demanding combat MOSs. The seven Combat Arms MOSs are: 11B Infantryman, 11C Infantryman-Indirect Fire, 12B Combat Engineer, 13B Cannon Crewmember, 13F Fire Support, 19D Cavalry Scout, and 19K Armor Crewman. Understanding the physiological demands placed on these MOSs will allow for the development of valid, safe and legally defensible physical performance tests to predict a Soldier's ability to serve in these MOSs. This is particularly important as the Army direct ground combat exclusion was lifted by the former Secretary of Defense (Leon Panetta), which will require the services to open these MOSs to females or justify the decision to keep them closed. Effective 16 JUN 2015, the 12B MOS was the first of these MOSs open to females (Army Directive 2015-27, see Appendix A).

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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


Currently, Soldiers in the U.S. Army are not selected for their MOS (Military Occupational Specialty) based on their ability to do the physical tasks necessary for that MOS. The U.S. Army Research Institute of Environmental Medicine (USARIEM) was tasked by the Training and Doctrine Command (TRADOC) to develop criterion-based physical requirements for entry into seven physically demanding Combat Arms MOSs, including the 12B Combat Engineers.

Researchers from USARIEM completed three studies to develop a valid, safe, and legally defensible physical performance battery to predict a Soldier's ability to serve in this MOS. Study 1, conducted in September 2013, involved measuring and identifying the physiological requirements of each of the tasks of the MOS in order to identify a set of criterion tasks encompassing the physical demands of all of the jobs of the MOS. A group of female Soldiers were included in this sample in order to obtain data from both genders. For all tasks, at least 50% of the women were able to successfully complete the task to standard. From the physiological data, as well as incorporating data from focus groups, the casualty evacuation, casualty drag, sandbag carry and foot march were identified as representative of all heavy lift, heavy drag, lift and carry and load carriage tasks.

With these criterion tasks identified and vetted by SMEs, it was important to determine whether selected task simulations were reliable to use as criterion tasks for development of a model. Study 2, conducted in May 2014, involved developing task simulations of these four tasks (casualty evacuation, casualty drag, sandbag carry, and foot march). All four of the criterion tasks were determined to have sufficient reliability to use in development of a final predictive model.

Finally, once reliable criterion tasks were developed, predictive models of criterion task performance were developed (Study 3, July 2014). Four models were proposed to fit a range of needs of the Army (i.e., cost and space requirements). Potential predictor tests included 300 m sprint, 2-min arm ergometer, beep test, medicine ball put, 1-min sit-up, 1-min push-up, standing long jump, and 38 cm upright pull.

With the test battery models developed, future work will require TRADOC to select a testing battery and identify acceptable performance on the criterion tasks in order to identify appropriate cut scores.

**Note:** The test batteries presented in this report apply only to the 12B. Additional technical reports will be written for the Field Artillery, Infantry and Armor MOSs. A final report will be written to develop one overarching test battery of five to seven tests to cover all seven MOSs. This final common Combat Arms model may vary from those presented in this report.

## Study 1: Physiological Observation

## STUDY 1: INTRODUCTION

According to Payne & Harvey (25), the first steps in developing a physical testing battery are to identify the most physically demanding tasks and then quantify the physiological demands of the individual tasks. TRADOC began by reviewing field manuals training videos, and physical task descriptions related to each of the MOSs (11B Infantryman, 11C Infantryman-Indirect Fire, 12B Combat Engineer, 13B Cannon Crewmember, 13F Fire Support, 19D Cavalry Scout and 19K Armor Crewman). A group of subject matter experts (SMEs) from each of the proponent schools then developed a task list and associated minimum standards based on this review. The result was a list of 32 physically demanding tasks essential to these MOSs (Table 1.1). Of these tasks, nine were common to several MOSs, and 23 were specific to one or two MOSs. TRADOC then observed Soldiers from each MOS performing the tasks. If 90% of the Soldiers observed could not perform the tasks to standard, the task statements were revised until the 90% threshold was reached. As part of this TRADOC exercise, USARIEM researchers also observed the Soldiers. Quantifiable task details were recorded including quantity and weights of loads being moved or lifted, distances traveled, Soldier gear and equipment required.

USARIEM researchers also conducted focus groups with enlisted Soldiers of each MOS. Both lower enlisted (Corporal/Specialist and below) and upper enlisted (Sergeant through Sergeant First Class) Soldiers completed surveys about each of the tasks identified as relevant to their MOS. Soldiers were asked how often they completed the tasks both in training and while deployed in order to better understand the frequency of performing the task. This was followed with a face-to-face focus group session where Soldiers were asked about the details collected during phase one, such as if the weights and distances were correct and if there were any additional tasks which warranted consideration (18).

With the first two steps (task validation and focus groups) complete, the next phase of the project required the direct measurement of the physically demanding tasks. Quantifiable metrics of task performance and physiological response were collected from members of each of the MOSs. These measurements included heart rate, ratings of perceived exertion and metabolic cost. In addition to male 12B Soldiers, female Soldiers from other MOSs also performed the tasks in order to include physiological responses from both sexes. These data were used to select the most physically demanding tasks for each MOS and to develop criterion task simulations.

Combat Engineer (12B) duties include constructing fighting and defensive positions, placing detonating materials, detecting explosives, clearing routes and creating and clearing obstacles for missions. The 12Bs are in the top cluster of physically demanding MOSs, in that they have both heavy strength and aerobic demands (38). While a number of their tasks have been identified as having high physical demands, the exact physiological requirements of these tasks had not been quantified.

## STUDY 1: METHODS

Data were collected at Ft. Hood, TX during September 2013 from Soldiers of the 1st Armored Brigade Combat Team, 1st Cavalry Division. Physiological measurements were collected on 23 males with MOS 12B and 11 females from other MOSs (n=5, 88M Motor Transport Operator; n=1, 91B Wheeled Vehicle Mechanic; n=2, 92A Automated Logistical Specialist; n=2, 92F Petroleum Supply Specialist; and n=1, 94E Radio and Communications Security Repairer) while performing the 12B Combat Engineer tasks. Prior to testing, all Soldiers were briefed, signed a consent form, and completed questionnaires about their demographics and most recent Army Physical Fitness Test (APFT). Height and weight were also collected prior to the start of testing.

All participants completed a training and deployment history questionnaire (see Appendix I). Participants were asked the duration of their Army service, time in the MOS, and time deployed. Then, for each of the tasks, Soldiers were asked if they had performed the task in training or while deployed (if applicable) and how many times they had performed each task in either setting.

Prior to testing, all Soldiers were offered familiarization with the tasks. See Appendix E for details of the training schedule.

### TASK SIMULATIONS

Thirteen tasks were identified by TRADOC as relevant to the 12Bs (see Table 1.2). Employing hand grenades (Task 2), however, was not tested because it has been demonstrated that skill plays a bigger role than physiological demand and that task performance is not always repeatable (34). Of the 12 remaining tasks, three of the tasks (prepare a fighting position, casualty evacuation and install a Volcano) were divided into two parts for the purpose of understanding the unique demands of different aspects of the task. For preparing the fighting position (Task 3), the two aspects were sandbag filling and sandbag carrying segments. For casualty evacuation (Task 4b), Soldiers were tested from both the outside and inside position. Finally, for the install of a volcano (Task 31), Soldiers were measured from both the ground and truck position. For all team tasks, females had male teammates. If the team did not complete the task, each team member was allowed to repeat the task with a different teammate.

During each task, Soldiers wore the designated uniform (with associated load), as defined by the SMEs from the Combat Engineer School. The full breakdown of each load is illustrated in Appendix C. Briefly, the approximate weight of the basic Army Combat Uniform (ACU) was 12.4 lb. The fighting load includes the uniform plus the weight of the personal protective equipment (PPE) and weapon (70.4 lb) for a total of 83 lb. The loads varied based on the size of the Soldier, particularly the weight of the body armor. The weight of the standard PPE can vary from 63.1 to 77.5 lb. The loads worn for each task are listed in the task descriptions. The 24-hour sustainment load consisted of everything included in the fighting load, plus 19 lb of additional supplies and equipment carried in an assault pack, for a total load of 102 lb. This load also varies from 94 to 110 lb based on Soldier size. The task specific uniform can vary between 42.5 and 57.1 lb, which includes the ACU, Improved Outer Tactical Vest (IOTV) with Enhanced Small Arms Protective Insert (ESAPI) and Enhanced Side Ballistics Insert (ESBI) and Advanced Combat Helmet (ACH). The loads stated herein refer to size large body armor, so the loads represent the middle of the actual range of weight worn.

Descriptions of the testing condition for each 12B relevant task, as well as the acceptable standard of completion provided by TRADOC (when applicable), are listed below. All testing instructions and data sheets for Study 1 can be found in Appendices H and I, respectively.

**1. Foot March (Figure 1.1)**
**Conduct a Tactical Movement**

The standard tactical movement requires Soldiers to complete a 12-mi foot movement, wearing the 24-hour sustainment load (approximately 102 lb of equipment) in 24 hours. To obtain an estimate of energy expenditure during the task, Soldiers performed a 20-min movement at 2 to 2.5 mph with no grade. The purpose of this measurement was to determine the energy cost of the task, not to determine if Soldiers could complete a 12-mi foot march. The 20 min of exercise was adequate to achieve a steady metabolic state.

**Army Standard: Successful completion of the task**

**2. Employ Hand Grenades (NOT TESTED)**

While wearing a fighting load without a weapon (approximately 71 lb), throw a 1-lb hand grenade at least 30 m.

**3. Fighting Position (Figure 1.2)**
**Prepare a Fighting Position**
***Part A: Sandbag Fill***

While wearing a fighting load (approximately 83 lb), Soldiers shoveled sand from a large pile of loose sand into a bucket (to simulate a sandbag), using an entrenchment tool. A bucket was used to standardize the amount of sand moved. Soldiers filled buckets 55 to 60% full (30-40 lb of sand) 26 times.

**Army Standard: Fill 26 sandbags in 52 min**

***Part B: Sandbag Carry***

The Soldier lifted and carried 26 pre-filled sandbags, weighing 40 lb each, a horizontal distance of 10 m, where they built a fighting position within 26 min. The fighting position consisted of three rows in a rectangular formation. Each row consisted of three sandbags in length and three sandbags in height. One of the three rows only had two sandbags on the third level.

**Army Standard: Carry 26 sandbags in 26 min**

**4a. Casualty Drag (Figure 1.3)**
**Drag a Casualty to Immediate Safety (Dismounted)**

Upon auditory signal, Soldiers dragged a simulated casualty (approximately 270 lb) a distance of 15 m as quickly as possible while wearing a fighting load (approximately 83 lb). For the simulated casualty, a Survivor dummy (Dummies Unlimited, Pomona, CA) was modified to obtain the necessary weight. The dummy was outfitted with a modified Fighting Load Carrier to serve as a pulling handle.
**Army Standard: Casualty dragged 15 m in 1 min**

**4b. BFV Casualty Evacuation (Figure 1.4)**
**Remove a Casualty from a Vehicle (Mounted)**
As part of a two-Soldier team and while wearing a fighting load minus the weapon (approximately 71 lb), Soldiers removed a simulated casualty (approximately 207 lb, prorated at 103.5 lb/Soldier) from the commander's seat of a Bradley Fighting Vehicle (BFV). In order to standardize conditions, which would be impossible using a standard dummy with limbs that may catch in an irregular manner, the simulated casualty for this task was a haul bag (Black Diamond Zion, Salt Lake City, UT) modified to include straps that simulate the shoulder straps of a Combat Vehicle Crewman protective vest. Soldiers performed this task twice, once from the outside position, and once from the inside.
**Army Standard: Casualty removed from vehicle in 2 min**

**5. 25 mm Barrel Install (Figure 1.5)**
**Lift, Carry, and Install the Barrel of a 25 mm gun on the BFV**
As part of a two-Soldier team and wearing a fighting load (approximately 83 lb), Soldiers lifted, carried (25 m) and emplaced the barrel of the M242 25 mm gun (107 lb, prorated at 53.5 lb/Soldier) for the BFV. This involved placing the barrel onto the hood of the BFV, and climbing up onto the hood/deck. The Soldiers took turns supporting the barrel, while the other Soldier climbed onto the BFV. Once on the hood, the barrel was lifted as a team, and rotated into place.
**Army Standard: Successful completion of the task**

**6. Feeder Assembly (Figure 1.6)**
**Remove the Feeder Assembly of a 25 mm gun on the BFV**
While wearing a task specific uniform (approximately 49 lb), a Soldier removed the M242 feeder assembly (59 lb) from the gun on the BFV and placed it on the floor in the rear of the vehicle. This involved lifting, pulling and lowering the assembly out of the slot, holding it while moving across the vehicle seat, and placing it on the floor behind the seat.
**Army Standard: Successful completion of the task**

**7. Ammo Can Carry (Figure 1.7)**
**Load 25 mm HEI-T Ammunition Cans onto the Bradley Fighting Vehicle**
While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers lifted 30 cans of 25 mm ammunition (45 lb), carried them 15 m and placed them onto the tailgate of a BFV or a platform of similar height and

dimensions. The can dimensions were 36 x 33 x 13 cm. Soldiers carried one or two cans at a time.
**Army Standard: Successful completion of the task**

**27. Anti-Personnel Obstacle Breaching System (APOBS; Figure 1.8)**
**Carry and Emplace the APOBS**
While wearing approximately 83 lb fighting load, Soldiers walked on a treadmill, carrying the APOBS on their back (68 lb) at a 2 mph (3.5 km/hr) pace for 2 km.
**Army Standard: Move APOBS 2-km in 60 min**

**28. Cratering Charge (Figure 1.9)**
**Carry and Emplace the H6 Cratering Charge**
While wearing a fighting load (approximately 83 lb), Soldiers lifted and carried H6 Cratering Charges (40 lb), from a stockpile location to an emplacement area 100 m away. This was performed until three charges were moved. Soldiers carried one or two cratering charges at a time.
**Army Standard: Successful completion of the task**

**29. Modular-Pack Mine System (MOPMS; Figure 1.10)**
**Carry and Emplace the MOPMS**
As part of a two-Soldier team, each wearing a fighting load (approximately 83 lb), Soldiers lifted and carried the Modular-Pack Mine System (MOPMS) (160 lb prorated 80 lb/Soldier) from transport vehicle to emplacement area (100 m). The vehicle bed height was 2 m. Soldiers grasped the side handles of the MOPMS and lowered it to the ground, then carried it 100 m and placed it on the ground. The MOPMS has side handles and pop-out stretcher-like handles. Soldiers were permitted to carry with either set of handles.
**Army Standard: Successful completion of the task**

**30. Bailey Bridge (Figure 1.11)**
**Lift and Carry Rocker Roller During Construction of a Bailey Bridge**
As part of a two-Soldier team, each wearing a fighting load (approximately 83 lb), Soldiers lifted and carried the rocking roller (206 lb, prorated 103 lb/Soldier) a distance of 50 m.
**Army Standard: Successful completion of the task**

**31. Volcano (Figure 1.12)**
**Load and Install a Volcano Mine System**
As part of a four-Soldier team, each wearing a 16-lb fighting load, Soldiers lifted into and installed a Volcano Mine System (beam frame, two tripod assemblies, and two launcher racks) in the cargo bed of a Family of Medium Tactical Vehicle (FMTV). All lifts were performed by two Soldiers to approximately 2 m in height. The weight of the components ranged from 151 to 370 lb (prorated 75.5 to 185 lb/Soldier). Soldiers completed this task in teams both from the ground and vehicle position.

**Army Standard: Successful completion of the task**

Soldiers were instructed to perform the tasks at the rate they would normally perform the task. All tests were graded "Go" or "No-Go," depending on whether they completed the task to standard. Because the foot march task was modified from the testing standard (completing a full foot march), Soldiers were graded only on whether or not they completed the 20 min foot march.

## PHYSIOLOGICAL MEASUREMENTS

Measurements varied by task (see Table 1.2). Time to completion was recorded for all tasks. Ratings of perceived exertion (RPE; (4)) were also recorded for all tasks, with those tasks deemed aerobically-intensive graded on the 6-20 scale (Tasks 1, 3, 7, 27, 28, and 31), and tasks primarily driven by strength (Tasks 4a, 4b, 5, 6, 29, and 30) graded on the CR-10 (i.e., 1-10) scale. Tasks with an approximate duration of greater than 5 min were deemed aerobic tasks, while the remaining were identified as strength tasks.

Metabolic data were also collected for the aerobic tasks using either a Parvo Medics TrueOne 2400 Cart (Sandy, UT) for Tasks 1 and 27, or an Oxycon Mobile Metabolic Unit (CareFusion, San Diego, CA) for Tasks 3, 7, 28, and 31. Data were output using 1-min averaging, and then were averaged over the course of the task, leaving out the first minute. Metabolic variables of interest included average heart rate (HR), average rate of oxygen uptake ($VO_2$) in absolute units (L/min), average $VO_2$ relative to body mass (ml/kg/min), and percent of estimated $VO_2max$. $VO_2max$ was estimated using the following equation (21):

$$\text{Predicted } VO_2max\ (ml \cdot kg \cdot min^{-1}) = 110.9 - 2.79\ (\text{2-mi run time [min]}) - 0.25\ (\text{weight [kg]})$$

Absolute total $O_2$ consumption (L, product of average $VO_2$ and time) and total adjusted for body mass (ml/kg) was also calculated. For all tasks, except Tasks 5 and 6, HR at the end of the task was recorded using a Polar heart rate chest-strap monitor and watch (Polar Electro Model T31, Kempele, Finland).

## STATISTICAL ANALYSES

All statistics were calculated using SPSS Version 20 (IBM Corporation, Armonk, New York). Significance was set at the $p<0.05$ level. For each task and outcome variable, mean and standard deviations were calculated separately by sex. Differences between sexes in characteristics were assessed using unpaired t-tests. Sex differences in percentage of individuals who completed the task to standard were assessed using a Pearson's chi-square test. Two-factor (task, sex) ANOVAs were run for each physiological variable using data from those who successfully completed the task. The aerobic and strength tasks were tested separately. Significant main effects of task were separated using a post-hoc Scheffe's adjustment to determine differences in physiological demand across tasks. Marginal means were calculated by task for the interaction, and tested using post-hoc unpaired t-tests for differences across in the physiological demands by sex for each task.

## <u>STUDY 1: RESULTS</u>

### SOLDIER VOLUNTEER CHARACTERISTICS

Characteristics of the Soldiers tested are summarized in Table 1.3. Briefly, the males and females were similar in age ($p=0.16$), but the males were taller and heavier than the females ($p<0.01$). Ranks of the participants include two Privates (2M), 10 Private First Class (9M, 1F), 17 Specialists (8M, 9F), and five Sergeants (4M, 1F). Males and females had similar times in the military, in their present MOS, or deployed ($p\geq0.15$). The groups were similar in APFT scores ($p=0.74$). However, the males had faster 2-mi times ($p<0.01$).

The data from the training and deployment questionnaire are shown in Table 1.4. Training data indicates that all of the 12B Soldiers performed all 12 of the tasks at some point during their training. The most commonly performed aerobic tasks completed in training by the full group were the foot march and ammo can carry, likely because these were both common MOS tasks. In a deployed setting, the foot march and the cratering charges were the most common aerobic tasks. The 25 mm barrel install and removal of the feeder assembly were the most common strength tasks both in training and deployed settings. Notably, none of the eight previously deployed 12B Soldiers indicated having performed APOBS, MOPMS, Bailey bridge or installing a Volcano while deployed, all of which are specific to their MOS.

### TASK COMPLETION

Table 1.5 indicates the number of participants tested for each task, as well as the number who completed each task to the standard. Due to the time required to complete the tasks and collect the metabolic data, not all Soldiers performed the fighting position or volcano tasks. One female participant was injured on the first day of testing and could not complete testing on the following days.

Of those who attempted the tasks, all but five tasks were completed by all to standard. Of the aerobic tasks, two of seven females did not complete the sandbag carry to standard (under 26 min), and five females and two males were unable to complete the APOBS. Of the strength tasks, five of 11 females were unable to complete the casualty drag. Two females and one male were unable to perform the casualty evacuation from the top position, and one female was unable to do it from the bottom position. One female was unable to carry the rocking roller of the Bailey bridge. Completion percentages were lower for the females for the fighting position ($p=0.03$), APOBS ($p=0.01$), and casualty drag ($p<0.01$).

### PHYSICAL DEMANDS OF TASKS

Physiological data were calculated only for individuals who completed the task to standard to ensure that the data corresponded to acceptable performance. Times to task completion for the aerobic and strength tasks are shown in Figure 1.13 (TOP). The aerobic tasks that took the longest were the foot march, both phases of the volcano and the APOBS. Tasks perceived (Figure 1.14, TOP) to have the greatest exertion were both phases of the fighting position, ammo can carry, APOBS and truck phase of the volcano. The greatest end-task HRs (Figure 1.15, TOP) were observed during the sandbag carry, ammo can carry, APOBS and cratering charge. When measuring average HR during aerobic tasks (Figure 1.16), the truck phase of the volcano as well the sandbag carry, ammo can carry, APOBS and cratering charge, ranked highest. No matter how the rate of oxygen consumption was normalized (Figure 1.17), the tasks with the greatest average rates were the sandbag carry, ammo can carry and cratering charge. The greatest total oxygen consumption (a surrogate for total energy expenditure), both in terms of absolute or adjusted for body mass (Figure 1.18), was observed during the APOBS and the volcano.

The Bailey bridge took the longest of the strength tasks (Figure 1.13, BOTTOM). The Bailey bridge, along with the casualty drag, was perceived to require the greatest exertion of the strength tasks (Figure 1.14, BOTTOM). Casualty drag, MOPMS and Bailey bridge all were in the top tier of end-task HRs for the strength tasks (Figure 1.15, BOTTOM).

A summary of tasks deemed most difficult for each measure, by nature of being in the top rank, is provided in Table 1.6.

## SEX DIFFERENCES IN PHYSIOLOGICAL MEASUREMENTS

Females took longer to complete the aerobic tasks of the sandbag fill, ammo can carry, APOBS and truck phase of the Volcano ($p \leq 0.03$). Perceived exertion was higher in the females for the foot march, ammo cans and both phases of the volcano ($p \leq 0.01$). Heart rate at the end of the task was higher in the females for the foot march and ground phase of the volcano ($p \leq 0.03$); however, average heart rate was only higher in the females for the foot march ($p < 0.01$). Average rates of oxygen consumption on an absolute scale were greater in the males for both phases of the fighting position, ammo can carry, APOBS, cratering charges and truck phase of the volcano ($p \leq 0.01$). When normalized to body mass, average rates of oxygen consumption were still higher in the males for both phases of the fighting position, ammo can carry, APOBS and cratering charges ($p \leq 0.04$). However, when normalized to predicted $VO_2max$, oxygen consumption was greater in the males during only the ammo can carry and APOBS ($p \leq 0.02$). In terms of absolute total oxygen consumption, males had higher costs during the sandbag carry, APOBS and both phases of the volcano ($p \leq 0.03$). When normalized to body mass, the only sex difference was a higher relative oxygen consumption in the females during the ammo can carry ($p=0.01$).

Of the strength tasks, females or teams with females, took longer to complete the casualty drag and the Bailey bridge ($p \leq 0.02$). Perceived exertion was higher in the females for casualty drag, feeder assembly, MOPMS and Bailey bridge ($p \leq 0.01$). End heart rate was higher in the females only during the MOPMS ($p=0.02$).

A summary of sex differences by task for each measure is provided in Table 1.7.

## STUDY 1: DISCUSSION

This descriptive study identified the frequency and physiological demands of 12 of the most physically demanding tasks performed by 12B Combat Engineers. From these data, the foot march, ammo can carry, 25 mm barrel install and removal of the feeder assembly were identified as the most commonly performed tasks. Of the aerobic tasks, the sandbag carry and the ammo can carry ranked hardest in terms RPE, HR, and $VO_2$. The APOBS and truck phase of the volcano ranked highest based on time and total $O_2$. For the strength tasks, the casualty drag and Bailey bridge ranked hardest in terms of RPE and HR, while the Bailey bridge took the longest to complete.

## PHYSICAL DEMANDS OF TASKS

The sandbag carry and the ammo can carry are the most demanding repetitive lift and carry tasks. Notably, there is no statistical difference among any of the measures for these two tasks. This finding is not surprising, given the similarities of the tasks themselves. Both tasks involve moving a heavy object (sandbag: ~35 lb; ammo can: 45 lb) over a moderate distance (sandbag=10 m; ammo cans=15 m) and repeating this motion (sandbag=26x; ammo cans=30x). While there are subtle differences in the tasks, the physiological requirements of the tasks are very similar.

The energy requirements of the foot march suggest that it is not a physically demanding task; however, these results are deceiving. It is noteworthy that the difference in energy requirements and perceived exertion between the foot march, ammo can carry and sandbag carry task is due to the brief simulation of the foot march task using a treadmill. While the weights and speeds were matched to a typical foot march, the task should be performed over a much longer distance (12 mi) with more difficult terrain. While the foot march simulation in the present study may have captured the physical demand early in the march over flat ground, it likely failed to capture any increase in difficulty and discomfort due to hills and fatigue. TRADOCs' task standards validation data indicated that under certain conditions, as few as 59% of 237 Soldiers attempting the task were able to complete a 12-mi foot march. While many of these observations with high failure rates were observed in extreme heat, there was attrition during all of the TRADOC observations. Contrary to those observations, all 33 of the Soldiers in this study completed the 20-min simulation. Thus, while we measured the energy requirements early in the task, this study did not capture the full spectrum of physical demands of a foot march. It has been shown that energy expenditure during a load carriage task increases over time (24). Therefore, future studies should assess the physical demands of a complete tactical march (either through direct testing or simulations) in order to get a better understanding of the physiological response during the later phases of the march, particularly with the onset of physical fatigue.

A number of the tasks required teamwork in groups of two or more participants. These include the casualty evacuation, 25 mm barrel install, MOPMS, Bailey bridge and Volcano. During these tasks, the performance of one individual will affect the others performing the task. For example, the weaker person may be carrying less of the load, or a less aerobically fit individual may require the task be performed at a slower rate. Likewise, the more the stronger or fitter person is able to compensate for another Soldier, the less of a demand is placed on the weaker one. In addition, if the load is not distributed evenly, the task may not be the same for each member of the team. Thus, interpretation of the physical demands of these tasks should be performed with care, taking this influence into account. While the average data is still valid, given different combinations of individuals, it is likely that performance could be more variable. This is particularly true since tasks were completed at a work (i.e., submaximal) pace, and not necessarily at an all-out effort. Simulations must be designed to reflect the demands of a single individual to assess an individual's capacity to perform the task.

Of the three tasks, which were split into two parts, only one was found to have similar physiological demands on both parts. For the casualty evacuation, there were similar RPE and HR responses both from the Soldier pulling up from the top as well as pushing up from below. In contrast, there were differences in the two phases of the fighting position and volcano tasks. Heart rate and $VO_2$ were lower for the fill phase of the fighting position than the carry phase and lower for the ground phase of the Volcano than the truck phase.

## SEX DIFFERENCES IN PHYSIOLOGICAL MEASUREMENTS

The present study is unique in that it tested females performing simulations of tasks from a MOS currently closed to females. While several of the tasks are common to many MOSs, there were five tasks unique to 12B. It is not known how many times the females had been exposed to these tasks prior to this study; however, it is important to note that the females were not naive to the tasks. They were given two weeks of training on all tasks. It is also important to note that these females represent a random selection of volunteers, and the results may not be comparable to females who may show interest in joining the MOS in the future.

In regards to completing the tests to standard, there were three tests where we observed that females were less successful than males (Table 1.5). They were the sandbag carry, the casualty drag, and the APOBS. For the fighting position, two females completed the task, but were beyond the 26-min limit (taking 32 and 34 min). All five of the females who were unsuccessful on the casualty drag were able to complete the 15 m, but did not complete it within the required timeframe. For the APOBS, none of the five females who were unsuccessful completed more than 53% of the distance.

Differences in task performance by sex are summarized in Table 1.7. Notably, during the aerobic task, which was matched for pace (foot march), there was no difference in $VO_2$, but the RPE and heart rate were higher in the females than the males. In a task that was self-paced (ammo can carry), females were slower and worked at a lower $VO_2$ but had a matched level of exertion compared to the males. This may be due to a lower muscular or aerobic endurance in the females. Whatever the etiology of this strategy, it resulted in the females having greater total energy expenditure when normalized to body weight.

Females also perceived four of the seven strength tasks to be harder than the males. The three tasks in which women and men had similar RPEs were team tasks. While there is no record of their strength or their partner's strength, it is possible that an equilibrium of effort was established, independent of the actual amount of weight being carried. Females also found tasks with two of the three heaviest weights more difficult than the males both in RPE and time to completion. These include the casualty drag (270 lb) and Bailey bridge (prorated 103 lb). Strength was likely a limiting component in performance of these tasks.

**FUTURE TASK SIMULATIONS**

For the purposes of identifying predictor tests, it is possible to break down the tasks further based on their constituent movements. The tasks tested consist of both aerobically demanding tasks and strength demanding tasks. The aerobic tasks can be subdivided into repeated lift and carry tasks (fighting position, ammo can carry, cratering charges and volcano), and extended duration load carriage (foot march, APOBS). The strength tasks can be broken into heavy lift (casualty evacuation, 25 mm barrel install, feeder assembly, MOPMS and Bailey bridge) and heavy drag (casualty drag). Tasks identified for these simulations should:

- Test individuals, not teams
- Allow for a range of scores to show graded differences between people (cannot be go/no-go)
- Accurately measure unique physical capabilities
- Be safe (not endanger Soldiers)
- Require minimal, available equipment
- Be reliable (same person gets same score on different days)
- Require minimal skill and practice
- Be time efficient

Between the two load carriage tasks, it would initially appear that the APOBS is the more physically demanding task. However, as we previously stated, our simulation may have underestimated the physical demands of the foot march. In fact, our simulation (which would have maxed out at 0.83 mi) was approximately 67% of the distance completed in the 2-km APOBS test (which was completed to Army standard) or only about 7% of the distance of the 12-mi Army foot march standard. In addition, the materials for the APOBS are more difficult to acquire, and the task is conducted less frequently while in training and deployed. Thus, further evaluation of the physical demands of a full tactical march is suggested before determination of the best load carriage test can be made.

All of the repetitive lift and carry tasks were in the most physically demanding group for at least one of the measures (oxygen uptake, total $O_2$ cost, HR, RPE; Table 1.6). Three of them were in the most physically demanding for four different measures: sandbag carry, ammo can carry and truck phase of the Volcano. The Volcano has a high total $O_2$ cost, indicating that a lot of energy is used to complete the task, but that cost is due to the duration of the task. The task involves multiple people, and much of the time performing the task is spent waiting. It also requires specialized equipment and technical knowledge, so it may not be the best test for criterion validation studies. As previously mentioned, the ammo can carry and the sandbag carry have similar physical demands and are not highly skilled, thus either one is a likely candidate for use in future studies.

Among the strength tasks, the Bailey bridge resulted in the highest RPE of the heavy lift tasks. However, Bailey bridge components are difficult to obtain. It is a two-person carry task which would be hard to simulate as an individual task, and it is not frequently performed by Soldiers (18). The casualty evacuation has a prorated weight of 103.5 lb (similar to the Bailey bridge and greater than all other tasks), is easier to simulate as an individual task, is commonly performed both in training and deployed settings, and is important to the health and safety of the Soldiers. Thus, the casualty evacuation may be the better candidate for future task simulations.

The casualty drag should be simulated due to its unique motion and high physical demands (HR and RPE). It is a frequently practiced task and has life or death consequences.

**LIMITATIONS**

While this study was designed to simulate real world conditions, we were not able to account for all variables. Some tasks had to be modified to allow for testing (e.g., foot march on a treadmill, haul bag used for casualty extraction). Tasks were completed on four successive days, so any cumulative fatigue or discomfort may have affected performance on later days. While this may affect performance on individual tasks, it is not uncommon for Soldiers in the field to have to perform these physical tasks on consecutive days. In addition, several tasks were completed as teams of two or more people. This makes it difficult to fully understand the demands of the task on an individual, as the two Soldiers may not be evenly distributing the burden of the task.

Most notably, all tasks were tested in a controlled garrison environment. Soldiers were instructed exactly how to perform the task, based on recommendations provided by SMEs. It is possible that in a real situation, there may be variations on the task that may increase or decrease the individual demands, such as material on which the casualty is dragged, distance of carry (ammo cans, sandbags, Bailey bridge parts MOPMS) or weight of the casualty. In addition, at no time were the Soldiers in immediate danger. In a deployed, high-stress situation, the physiological demands are likely increased, and tasks may be performed repeatedly or in an entirely different manner.

**STUDY 1: CONCLUSIONS**

The present study determined the physiological demand for the TRADOC identified physical demanding tasks of 12B Combat Engineers. Among the most physically demanding aerobic tasks are the sandbag carry and the ammo can carry. Due to study design, it is unclear if the APOBS or foot march has greater physical demands. The casualty evacuation and Bailey bridge were the most physically demanding for the strength tasks, although the casualty drag should be considered for future testing, due to its high degree of relevance to Soldier well-being.

## STUDY 1: RECOMMENDATIONS

1. The foot march should be assessed using a full foot march in the field, so that the true physical demands can be compared to the simulation.

2. Tasks involving two or more people should be simplified into single person tasks so that demands on the individual can better be determined.

**Table 1.1.** List of the 32 Physically Demanding Tasks of Combat Arms Soldiers

| | TASK | IN 11B | IN 11C | EN 12B | FA 13B | FA 13F | AR 19D | AR 19K |
|---|---|---|---|---|---|---|---|---|
| 1 | Conduct Tactical Movement / Foot March | X | X | X | | X | X | X |
| 2 | Employ Hand Grenades | X | X | X | X | X | X | X |
| 3 | Prepare a Fighting Position (Fill and Emplace Sandbags) | X | X | X | X | X | X | X |
| 4a | Drag a Casualty to Immediate Safety | X | X | X | X | X | X | X |
| 4b | Remove a Casualty from a Wheeled Vehicle | X | | X | | X | X | |
| 5 | Maintain 25mm Gun on BFV – Install the Barrel | X | | X | | X | X | |
| 6 | Maintain 25mm Gun on BFV – Remove Feeder Assembly | X | | X | | X | X | |
| 7 | Load 25mm H-EIT Tracer Ammunition Can on BFV | X | | X | | X | X | |
| 8 | Load TOW Missile Launcher on BFV | X | | | | | X | |
| 9 | Move Over, Through, or Around Obstacles | X | X | | | | | |
| 10 | Move Under Direct Fire | X | X | [1] | | [1] | [1] | [1] |
| 11 | Prepare Dismounted TOW Firing Position | X | | | | | | |
| 12 | Engage Targets with a Caliber .50 M2 Machine Gun | X | | | | | | |
| 13 | Lay a 120mm Mortar – Emplace Base Plate | | X | | | | | |
| 14 | Lay a 120mm Mortar – Emplace Cannon | | X | | | | | |
| 15 | Lay a 120mm Mortar for Deflection and Elevation (Traverse) | | X | | | | | |
| 16 | Fire a Mortar (Lift and Hold Round, Place in Tube) | | X | | | | | |
| 17 | Mount M2 .50 Cal Machine Gun Receiver on an Abrams Tank | | | | | | | X |
| 18 | Stow Ammunition on an Abrams Tank (Load 120mm MPAT Round to the Ready Rack) | | | | | | | X |
| 19 | Load the 120mm Main Gun | | | | | | | X |
| 20 | Remove a Casualty from an Abrams Tank | | | | | | | X |
| 21 | Transfer Ammunition with an M992 Carrier (CAT) | | | | X | | | |
| 22 | Emplace 155mm Howitzer / Lift Wheel Assembly | | | | X | | | |
| 23 | Displace 155mm Howitzer / Recover Spade Trail Arm and Blade | | | | X | | | |
| 24 | Set Up Gun Laying Positioning System (GLPS) | | | | X | | | |
| 25 | Establish an Observation Point | | | | | X | | |
| 26 | Prepare M1200 Armored Knight Vehicle for Operation | | | | | X | | |
| 27 | Quickly Create a Footpath through Various Obstacles (Carry / Employ Antipersonnel Obstacle Breaching System (APOBS)) | | | X | | | | |
| 28 | Prepare Obstacle with the H6 40 lb Cratering Charge | | | X | | | | |
| 29 | Operate a Modular-Pack Mine System (MOPMS) | | | X | | | | |
| 30 | Assist in the Construction of a Bailey Bridge | | | X | | | | |
| 31 | Load / Install a Volcano | | | X | | | | |

*IN=Infantry, FA=Field Artillery, AR=Armor, EN=Engineers*

[1] Following Study 1, move under direct fire was determined to be essential to 12B, 13F, 19D and 19K as well.

**Table 1.2.** Summary of 12B MOS Specific Tasks and Measurements from Ft. Hood

| Task # | Occupational Related Task | Measures |
|---|---|---|
| | **Aerobic Tasks** | |
| 1 | Conduct a Foot March (Treadmill Simulation) | Time, RPE 6-20, HR, $VO_2$ |
| 3 | Prepare a Fighting Position (Fill and Emplace Sandbags) | Time, RPE 6-20, HR, $VO_2$ |
| 7 | Load 25 mm HEI-T Ammunition Cans onto the BFV | Time, RPE 6-20, HR, $VO_2$ |
| 27 | Carry and Emplace the Anti-Personnel Obstacle Breaching System | Time, RPE 6-20, HR, $VO_2$ |
| 28 | Carry and Emplace the H6 40-lb Cratering Charge | Time, RPE 6-20, HR, $VO_2$ |
| 31 | Load and Install a Volcano | Time, RPE 6-20, HR, $VO_2$ |
| | **Strength Tasks** | |
| 4a | Drag a Casualty to Immediate Safety (Dismounted) | Time, RPE CR10, HR |
| 4b | Remove a Casualty from a Vehicle (Mounted) | Time, RPE CR10, HR |
| 5 | Lift, Carry and Install the Barrel of a 25 mm Gun on the BFV | Time, RPE CR10 |
| 6 | Remove the Feeder Assembly of a 25 mm Gun on the BFV | Time, RPE CR10 |
| 29 | Carry and Emplace the Modular-Pack Mine System | Time, RPE CR10, HR |
| 30 | Lift and Carry Rocking Roller During Construction of Bailey Bridge | Time, RPE CR10, HR |

**Table 1.3.** Soldier Characteristics: Study 1

| | **Male (n=23)** | **Female (n=11)** | **p-value** |
|---|---|---|---|
| **Age** (years) | 22.3 ± 3.1 | 24.2 ± 4.2 | 0.16 |
| **Height** (cm) | 176.8 ± 6.1 | 164.0 ± 6.0 | <0.01 |
| **Mass** (kg) | 85.5 ± 9.5 | 70.1 ± 9.3 | <0.01 |
| | | | |
| **Time in Military** (years) | 2.0 ± 2.1 | 3.1 ± 1.9 | 0.15 |
| **Time in MOS** (years) | 1.9 ± 1.9 | 2.9 ± 2.0 | 0.19 |
| **Number Deployed** (%) | 8 (35%) | 6 (55%) | – |
| **Time Deployed** (years) *for only those who have deployed* | 1.4 ± 1.1 | 0.9 ± 0.3 | 0.33 |
| | | | |
| **Army Physical Fitness Test Score** (points) | 256.6 ± 38.0 | 252.0 ± 28.7 | 0.74 |
| **Push-ups** (# / 2 min) | 69.7 ± 9.3 | 38.6 ± 9.7 | <0.01 |
| **Sit-ups** (# / 2 min) | 69.4 ± 10.0 | 68.0 ± 7.8 | 0.70 |
| **Two-Mile Run Time** (min) | 14.4 ± 1.3 | 17.1 ± 1.6 | <0.01 |
| **Predicted $VO_2$max** (ml/kg/min) | 50.8 ± 4.8 | 47.2 ± 6.0 | 0.08 |

**Table 1.4.** Frequency of Task Performance in Training and Deployment Environments

| | | Males | | Females | |
|---|---|---|---|---|---|
| | | **In Training n=23** | **Deployed n=8** | **In Training n=11** | **Deployed n=6** |
| *Aerobic Tasks* | **1: Foot March** | 16.9 ± 16.3 (1-50) | 8.2 ± 12.2 (0-33) | 14.5 ± 26.0 (1-90) | 3.2 ± 4.1 (0-10) |
| | **3: Fighting Position** | 4.0 ± 4.3 (1-20) | 0.8 ± 1.7 (0-5) | 2.5 ± 1.6 (1-5) | 0.0 — |
| | **7: Ammo Cans** | 9.7 ± 22.4 (0-96) | 2.3 ± 5.5 (0-16) | 1.8 ± 1.8 (0-5) | 0.0 — |
| | **27: APOBS [a]** | 2.2 ± 4.1 (0-20) | 0.0 — | 2.3 ± 1.7 (0-5) | 0.0 — |
| | **28: Cratering Charge [a]** | 5.7 ± 7.2 (0-20) | 2.7 ± 5.5 (0-0) | 2.1 ± 1.8 (0-5) | 0.0 — |
| | **31: Volcano [a]** | 2.9 ± 4.0 (0-20) | 0.0 — | 3.2 ± 1.9 (0-5) | 0.0 — |
| *Strength Tasks* | **4a: Casualty Drag** | 5.6 ± 5.8 (1-20) | 0.2 ± 0.4 (0-1) | 4.0 ± 4.0 (1-15) | 0.3 ± 0.5 (0-1) |
| | **4b: BFV Cas Evac** | 4.3 ± 5.6 (0-20) | 0.2 ± 0.3 (0-1) | 3.6 ± 4.0 (1-15) | 0.4 ± 0.6 (0-1) |
| | **5: 25 mm Barrel Install** | 14.7 ± 24.0 (1-96) | 5.8 ± 11.2 (0-30) | 1.8 ± 1.5 (0-5) | 0.0 — |
| | **6: Feeder Assembly** | 14.8 ± 24.0 (1-96) | 3.9 ± 7.1 (0-16) | 2.1 ± 1.4 (0-5) | 0.0 — |
| | **29: MOPMS [a]** | 2.1 ± 4.0 (0-20) | 0.0 — | 2.1 ± 1.8 (0-5) | 0.0 — |

[a]: Data for MOS Specific Tasks while deployed shown only for male 12B Soldiers (n=8).

Values Mean ± SD (Range);
In Training: Total # of times task, *not including train-up for study;*
Deployed: Average # of times per year deployed.

**Table 1.5.** Number Tested and Completion Rates of Tasks

| | | Number Tested | | | Completion Rate | | | Gender Completion P-Value |
|---|---|---|---|---|---|---|---|---|
| | | All | Male | Female | All | Male | Female | |
| *Aerobic Tasks* | 1: Foot March | 33 | 23 | 10 | 100% | 100% | 100% | — |
| | 3: Sandbag Fill | 24 | 17 | 7 | 100% | 100% | 100% | — |
| | 3: Sandbag Carry | 24 | 17 | 7 | **91%** | 100% | **71%** | **0.02** |
| | 7: Ammo Cans | 33 | 23 | 10 | 100% | 100% | 100% | — |
| | 27: APOBS | 33 | 23 | 10 | **79%** | **91%** | **50%** | **0.01** |
| | 28: Cratering Charge | 33 | 23 | 10 | 100% | 100% | 100% | — |
| | 31: Volcano (TRUCK) | 25 | 18 | 7 | 100% | 100% | 100% | — |
| | 31: Volcano (GROUND) | 27 | 19 | 8 | 100% | 100% | 100% | — |
| *Strength Tasks* | 4a: Casualty Drag | 34 | 23 | 11 | **85%** | 100% | **55%** | **<0.01** |
| | 4b: BFV Cas Evac (TOP) | 32 | 23 | 9 | **91%** | **96%** | **78%** | **0.12** |
| | 4b: BFV Cas Evac (BOTTOM) | 32 | 23 | 9 | **97%** | 100% | **89%** | **0.10** |
| | 5: 25 mm Barrel Install | 33 | 22 | 11 | 100% | 100% | 100% | — |
| | 6: Feeder Assembly | 34 | 23 | 11 | 100% | 100% | 100% | — |
| | 29: MOPMS | 32 | 23 | 9 | 100% | 100% | 100% | — |
| | 30: Bailey Bridge | 33 | 23 | 10 | **97%** | 100% | **90%** | **0.12** |

**Bolding indicates <100% successful completion rate**

**Table 1.6.** Summary of Physical Demands of Tasks

| | | Prorated Load Carried[a] (lb) | Task in top rank of physical demand by: | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Time | RPE | End HR | Mean HR | $VO_2$ (absolute or relative) | Total $O_2$ (absolute or relative) |
| ***Aerobic Tasks*** | ***1: Foot March*** *Load Carriage* | *19.5* | † | | | | | |
| | ***3: Sandbag Fill*** *Repeated Lift & Carry* | *35* | | † | | | | |
| | ***3: Sandbag Carry*** *Repeated Lift & Carry* | *35* | | † | † | † | † | |
| | ***7: Ammo Cans*** *Repeated Lift & Carry* | *45* | | † | † | † | † | |
| | **27: APOBS** Load Carriage | 60 | † | † | † | † | | † |
| | **28: Cratering Charge** Repeated Lift & Carry | 40 | | | † | † | † | |
| | **31: Volcano (TRUCK)** Repeated Lift & Carry | 75.5 - 185 | † | † | | † | | † |
| | **31: Volcano (GROUND)** Repeated Lift & Carry | 75.5 - 185 | † | | | | | |
| ***Strength Tasks*** | ***4a: Casualty Drag*** *Heavy Drag* | *270* | | † | † | | | |
| | ***4b: BFV Cas Evac (TOP)*** *Heavy Lift* | *103* | | | | | | |
| | ***4b: BFV Cas Evac (BOTTOM)*** *Heavy Lift* | *103* | | | | | | |
| | ***5: 25 mm Barrel Install*** *Heavy Lift* | *53.5* | | | | | | |
| | ***6: Feeder Assembly*** *Heavy Lift* | *59* | | | | | | |
| | **29: MOPMS** Heavy Lift | 80 | | | † | | | |
| | **30: Bailey Bridge** Heavy Lift | 103 | † | † | † | | | |

[a]: Load does not include uniform
†: In top rank for measure (significantly greater than all other tasks, $p<0.05$)
*Italics: Task Common to Multiple Combat Arms MOSs*
Gray: Not measured

**Table 1.7.** Tasks with Sex Differences

| | | Time | RPE | End HR | Mean HR | $VO_2$ | Total $O_2$ |
|---|---|---|---|---|---|---|---|
| *Aerobic Tasks* | **1: Foot March** | F=M | F>M | F>M | F>M | F=M | F=M |
| | **3: Sandbag Fill** | F>M | F=M | F=M | F=M | ABS: F<M<br>REL: F<M<br>%MAX: F=M | F=M |
| | **3: Sandbag Carry** | F=M | F=M | F=M | F=M | ABS: F<M<br>REL: F<M<br>%MAX: F=M | ABS: F<M<br>REL: F=M |
| | **7: Ammo Cans** | F>M | F=M | F=M | F=M | ABS: F<M<br>REL: F<M<br>%MAX: F<M | ABS: F=M<br>REL F>M |
| | **27: APOBS** | F>M | F=M | F=M | F=M | ABS: F<M<br>REL: F<M<br>%MAX: F<M | ABS: M>F<br>REL: F=M |
| | **28: Cratering Charge** | F=M | F>M | F=M | F=M | ABS: F<M<br>REL: F<M<br>%MAX: F=M | — |
| | **31: Volcano (TRUCK)** | F>M | F>M | F=M | F=M | ABS: F<M<br>%MAX: F=M | ABS: F<M<br>REL: F=M |
| | **31: Volcano (GROUND)** | F=M | F>M | F>M | F=M | F=M | ABS: F<M<br>REL: F=M |
| *Strength Tasks* | **4a: Casualty Drag** | F>M | F>M | F=M | | | |
| | **4b: BFV Cas Evac (TOP)** | F=M | F=M | F=M | | | |
| | **4b: BFV Cas Evac (BOTTOM)** | F=M | F=M | F=M | | | |
| | **5: 25 mm Barrel Install** | F=M | F=M | | | | |
| | **6: Feeder Assembly** | F=M | F>M | | | | |
| | **29: MOPMS** | F=M | F>M | F>M | | | |
| | **30: Bailey Bridge** | F>M | F>M | F=M | | | |

$p<0.05$
M: Male, F: Female
For $VO_2$ and Total $O_2$, ABS: Absolute (L/min), REL: Relative to Body Mass (ml/kg/min), %MAX: Percent estimated $VO_2max$
Gray: Not measured

**Figure 1.1.** Image of Soldier Conducting a Simulated Foot March (Task 1)

**Figure 1.2.** Images of Soldier Building a Fighting Position (Task 3)

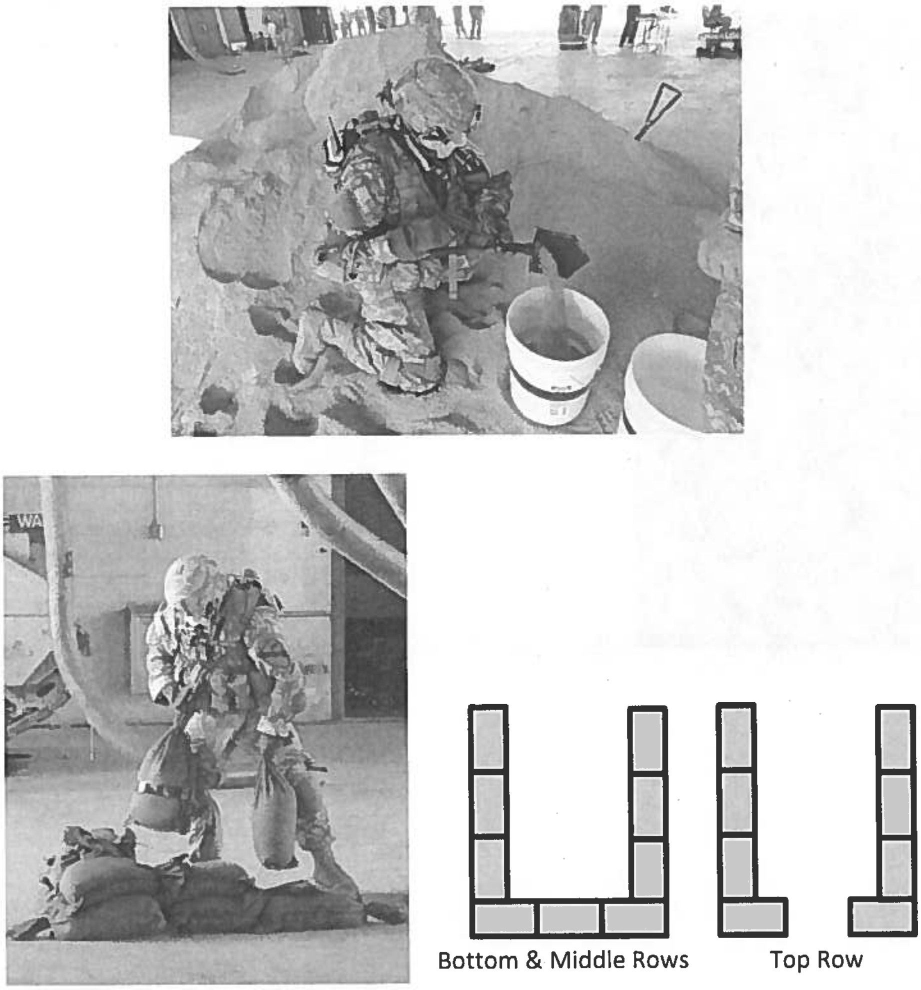


**Figure 1.3.** Image of Soldier Dragging the Simulated Casualty (Task 4a)

**Figure 1.4.** Image of Soldier Evacuating the Simulated Casualty from a BFV (Task 4b)

**Figure 1.5.** Image of Soldier Installing the Barrel of the 25 mm Gun on a BFV (Task 5)

**Figure 1.6.** Image of Soldier Removing the Feeder Assembly from the 25 mm Gun on a BFV (Task 6)

**Figure 1.7.** Images of Soldier Loading 25 mm HEI-T Ammunition Cans (Task 7)

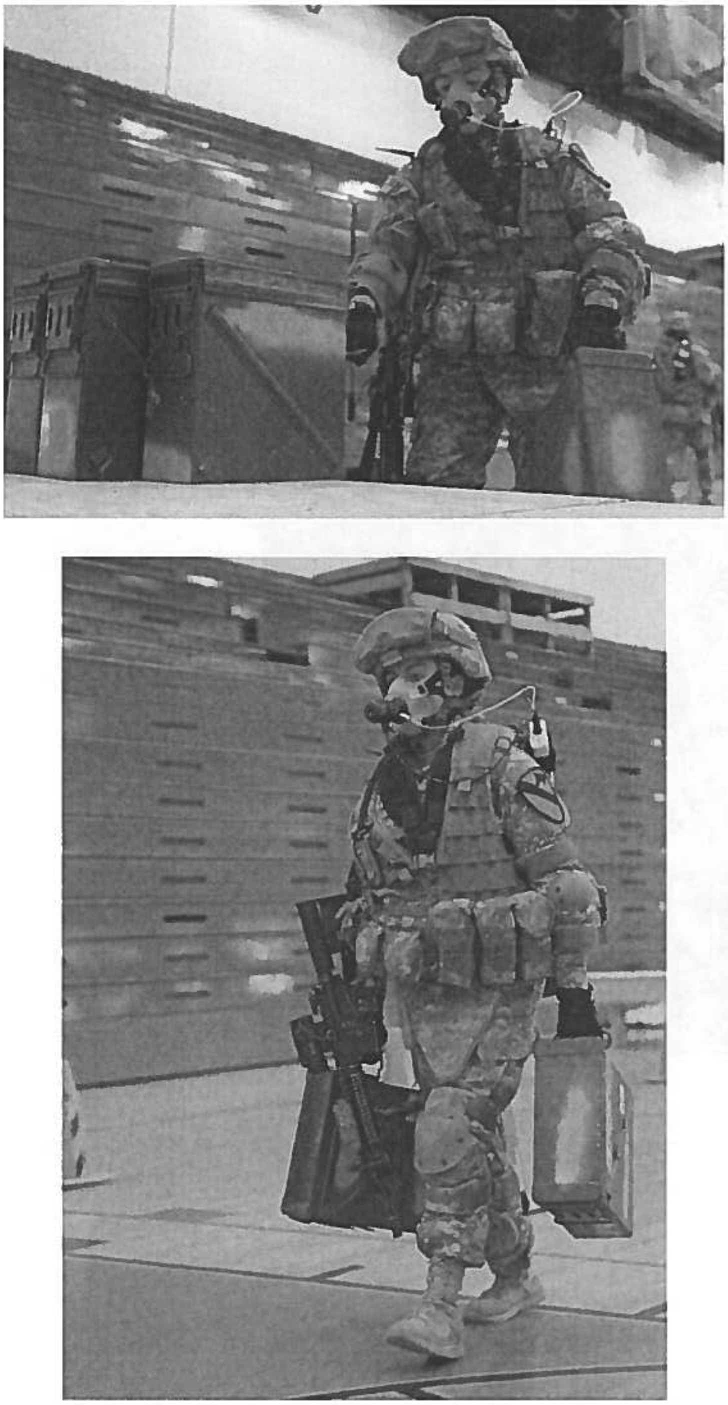


**Figure 1.8.** Image of Soldier Carrying the Anti-Personnel Obstacle Breaching System (Task 27)

**Figure 1.9.** Image of a Soldier Carrying the H6 40-Pound Cratering Charge (Task 28)

**Figure 1.10.** Image of Two Soldiers Carrying the Modular-Pack Mine System (Task 29)

**Figure 1.11.** Image of Two Soldiers Carrying the Rocking Roller of the Bailey Bridge (Task 30)

**Figure 1.12.** Images of Two Soldiers Loading and Installing the Volcano (Task 31)

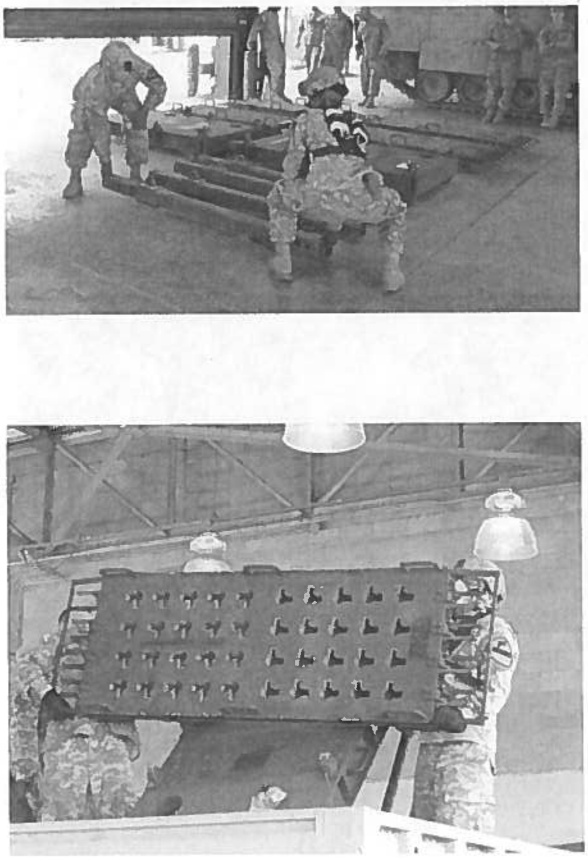
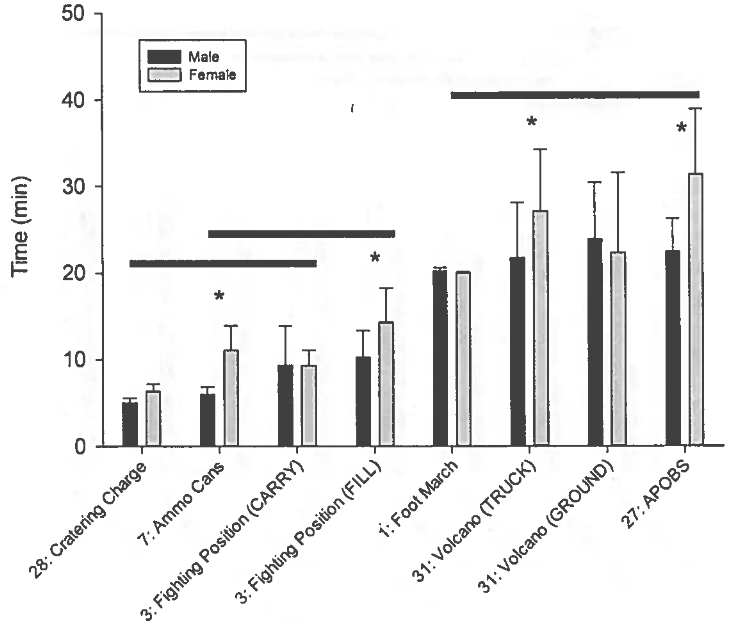
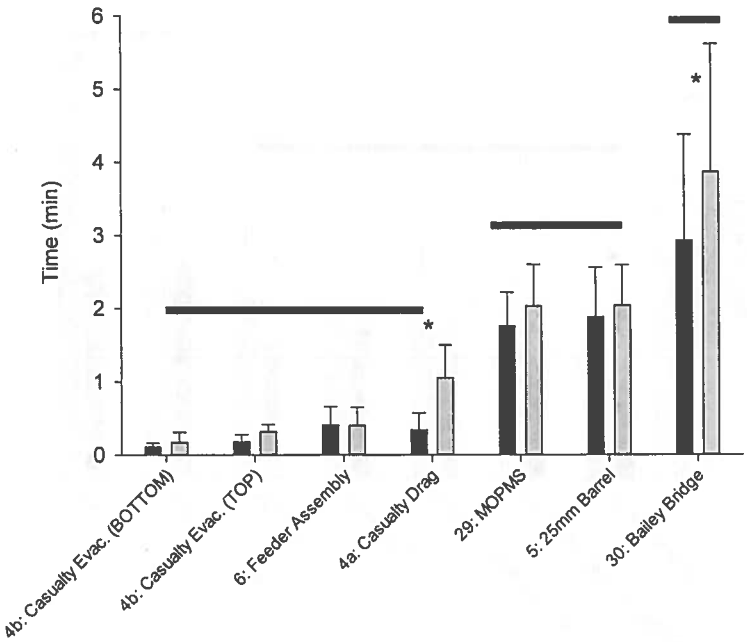


**Figure 1.13.** Time to Completion for Aerobic (TOP) and Strength (BOTTOM) Tasks

A) Aerobic Tasks



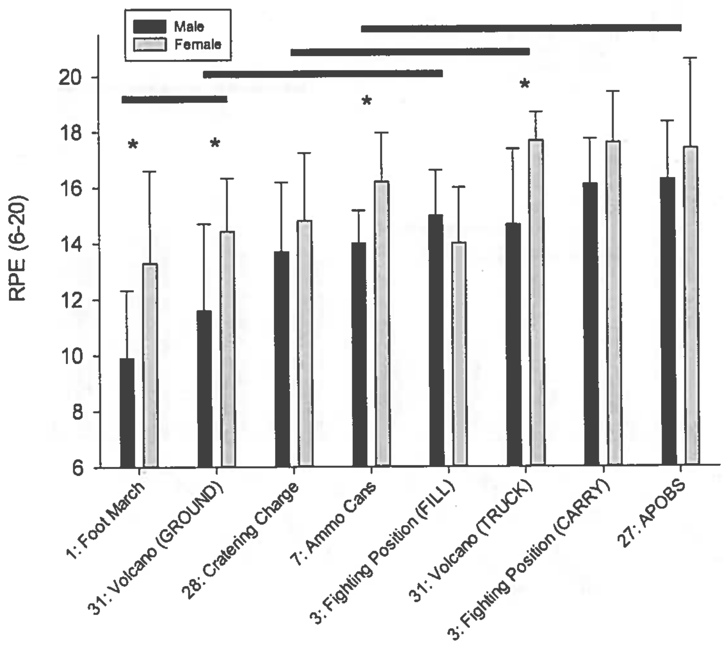

B) Strength Tasks



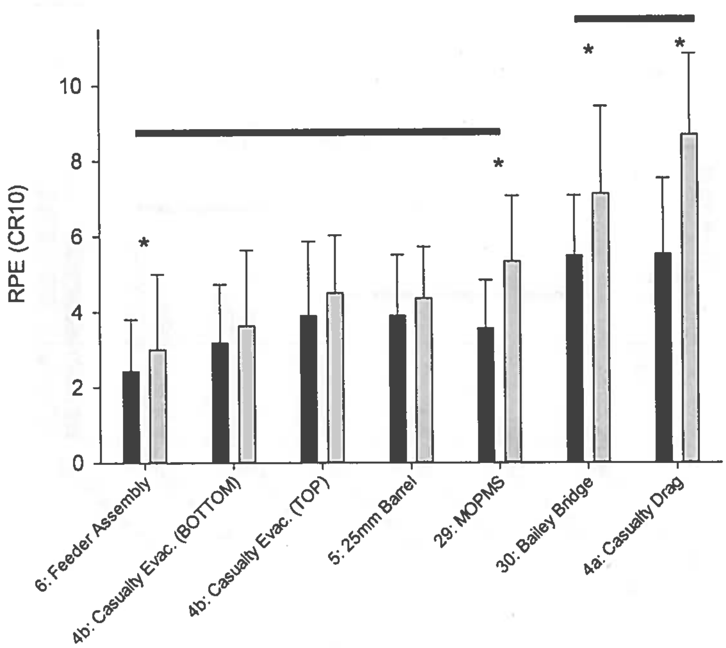

Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex (p≤0.05)

**Figure 1.14.** Ratings of Perceived Exertion for Aerobic (TOP) and Strength (BOTTOM) Tasks

A) Aerobic Tasks



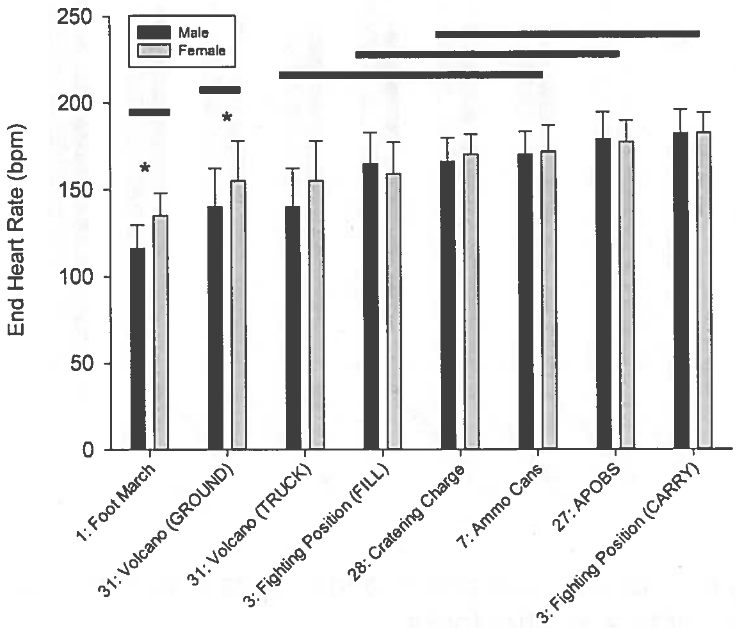

B) Strength Tasks



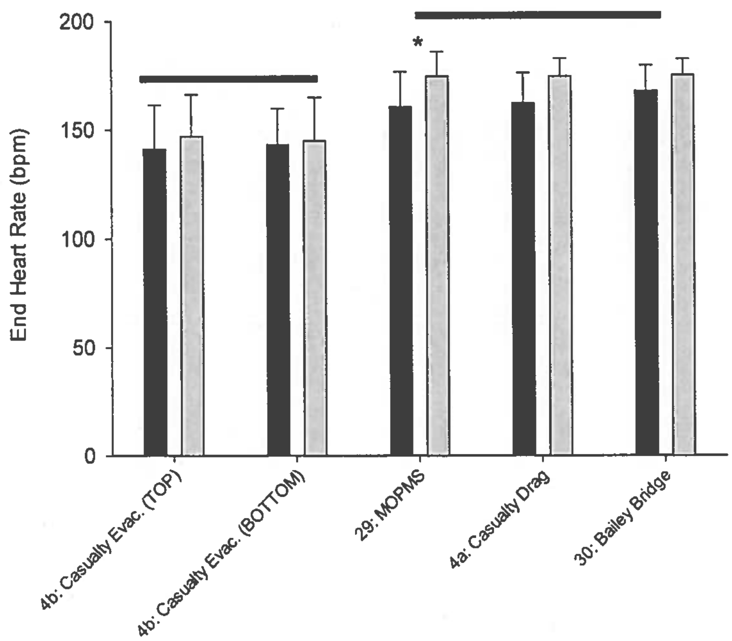

Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex (p≤0.05)

**Figure 1.15.** Heart Rate at the Completion of Aerobic (TOP) and Strength (BOTTOM) Tasks

A) Aerobic Tasks

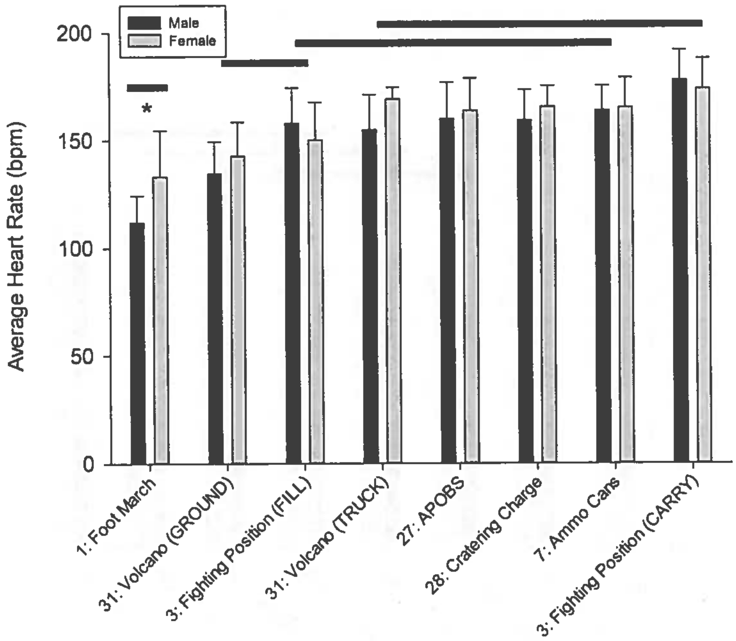



B) Strength Tasks




Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex (p≤0.05)

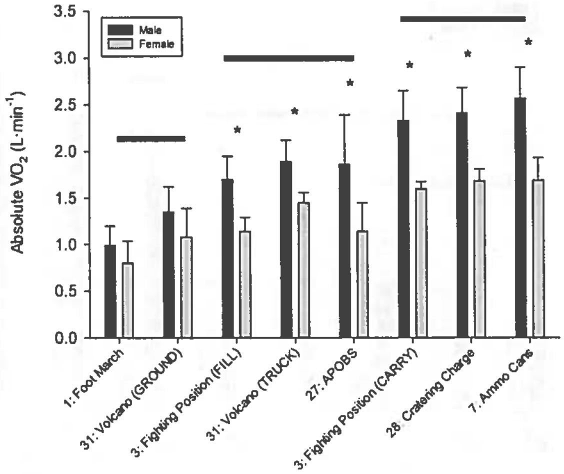
**Figure 1.16.** Average Heart Rate during Aerobic Tasks



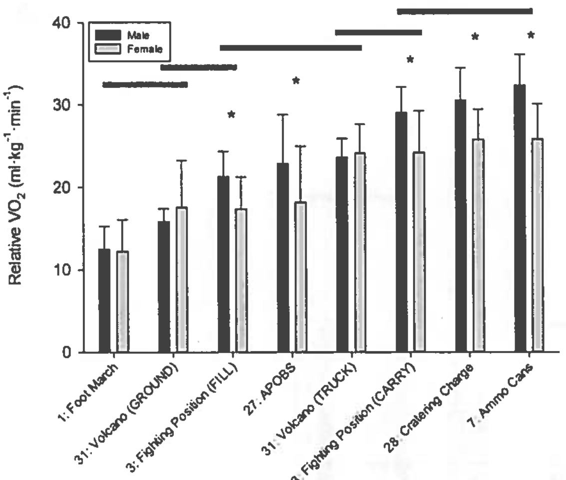

Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex (p≤0.05)

**Figure 1.17.** Average Absolute (TOP), Body-Mass Normalized (BOTTOM, LEFT), and Predicted $VO_2$max Normalized (BOTTOM, RIGHT) Rate of Oxygen Consumption during Aerobic Tasks

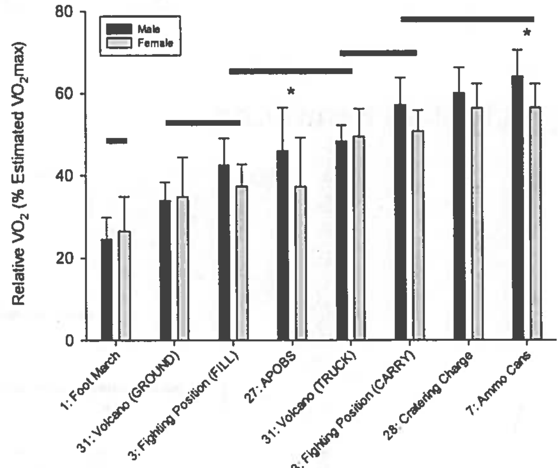
A.) Absolute




B.) Normalized to Body Mass



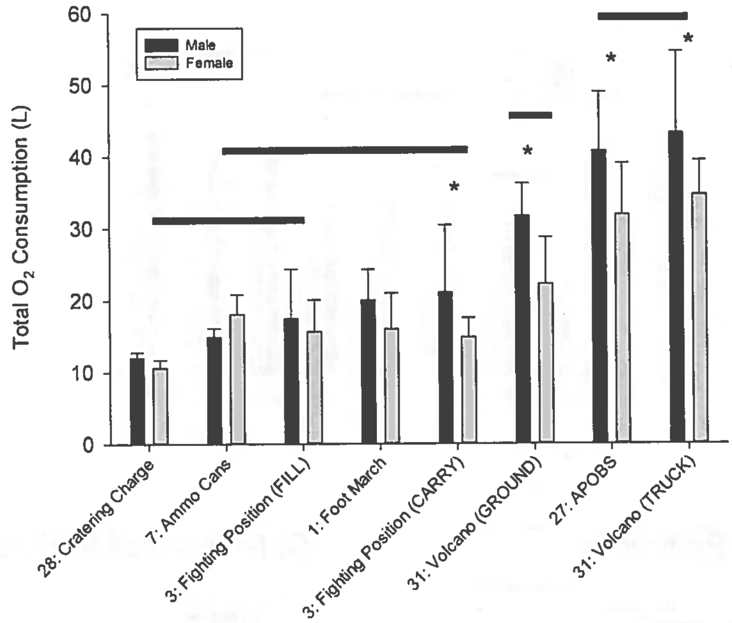

C) Normalized to Predicted $VO_2$ Max



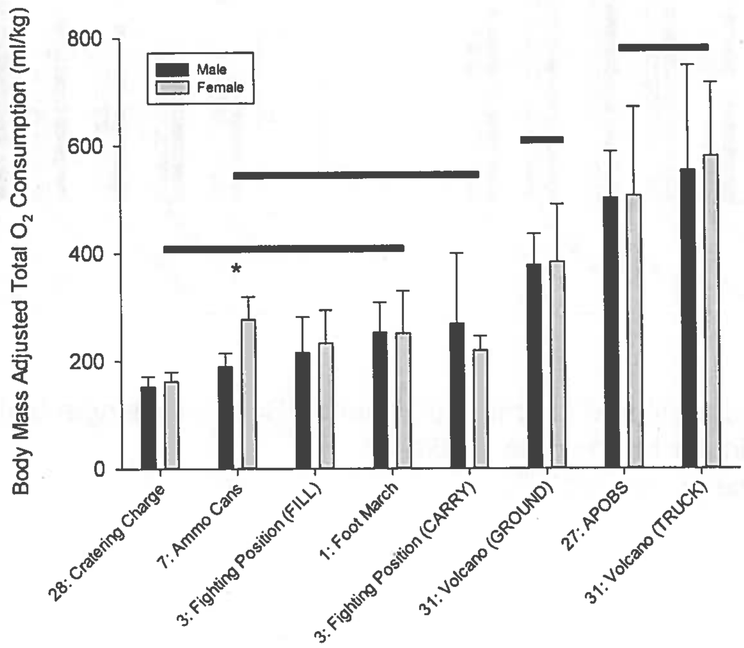

Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex ($p \leq 0.05$)

**Figure 1.18.** Absolute (TOP) and Body-Mass Normalized (BOTTOM) Total Oxygen Consumption during Aerobic Tasks

A) Absolute




A) Body Mass Normalized




Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.
* indicates difference by sex (p≤0.05)

## Study 2: Criterion Task Development and Reliability

### STUDY 2: INTRODUCTION

In Study 1, the physical demands of the critical physically demanding tasks of Combat Engineers were defined and compared across tasks. The large number of critical tasks identified for the Combat Engineers (12) required the down-selection of the task list to remove redundancies and include only the most physically demanding tasks within each task category (i.e., pulling, lifting, load carriage) and energy system (aerobic, strength, power). During this process, the frequency of performance of each task both in training and while deployed was considered, as well as the criticality of the test, both to the mission and the safety of others. The selected tasks became the criterion measure tasks for the Combat Engineer MOS. In order to develop a valid test to predict performance on these criterion measure tasks, a standardized simulation of each task was developed. These task simulations had to meet a number of requirements. The simulations must test individuals, not teams. Thus, any tasks involving more than one person needed to be deconstructed into a one-person task. The task simulations must allow for a range of scores to show differences between people and cannot simply be a pass/fail. Each task should measure unique physical capabilities, be safe and easy to administer and require minimal skill or learning. In order to test large numbers of Soldiers, the task simulations (as much as possible) should require minimal and available equipment and be time efficient. Most importantly, the tasks need to be reliable, meaning that the same individuals would have similar scores across repeated task trials.

### CRITERION TASK SELECTION PROCESS AND SUBJECT MATTER EXPERT (SME) APPROVAL

The 12 physically demanding Combat Engineer tasks from Study 1 were divided into four groups based on the physical domains of the tasks: heavy lift, repetitive lift and carry, heavy drag and load carriage. Based on the physical demands measured in Study 1, one task from each physical domain was selected to be a criterion measure task for the 12Bs. Removing a casualty from a vehicle was selected for the heavy lift. The casualty evacuation is the heaviest weight the 12Bs would be expected to lift, the task can be modified and assessed as an individual task with a range of scores, and is critical for the safety of other Soldiers. The sandbag carry was selected as the repetitive lift and carry because it was measured to be among the tasks with the highest ratings of perceived exertion, average heart rate and rates of oxygen consumption. In addition, it is common to all Combat Arms MOSs and the equipment is readily available. The casualty drag was selected for the heavy drag, given the uniqueness of the task and its importance in protecting the Soldier.

Two 12B tasks involve load carriage: emplacing the APOBS, and a foot march. Because the foot march simulation from Study 1 was determined not to be representative of the physiological demands of an actual foot march, data from a group of 19 series Soldiers were used to represent the foot march (unpublished data). The foot march was selected as the load carriage task over the APOBS. Despite carrying similar loads with similar or lower heart rates and ratings of perceived exertion as outcomes during a foot march, the distance of the foot march is longer, and it is common to six of the seven Combat Arms MOSs being evaluated. In addition, while most 12B in the focus group reported completing a foot march in a training and/or deployed environment, less than half of the 12Bs had performed the APOBS emplacement, and only one reported emplacing APOBS in a deployed setting.

A summary of the criteria for selecting the heavy lift task, lift and carry task, and load carriage tasks are summarized in Table 2.1. Thus, the final tasks selected as criterion measures were the casualty evacuation, casualty drag, sandbag carry and foot march. Three task simulations were truncated in order to optimize the time required for testing. With the sandbag carry, it was decided to truncate the task from the original 26 bags to 16 bags, as the $VO_2$ x repetition curve from Study 1 indicated that Soldiers reached a steady state by the completion of approximately 13 bags (Figure 2.1). The weight of the sandbags was increased to 40 lb, which was the upper end of the 30-40 lb range for sandbags provided by the task statements. This allowed the task to more closely mimic the ammo can carry (45 lb) while maintaining fidelity with the sandbag carry. Thirty seconds was determined to be the maximal time for the dummy drag, as 80% of the Soldiers could complete the 15 m within that timeframe (Figure 2.2). Finally, the distance for the foot march was shortened to 4 mi, based on data collected on four other MOSs (unpublished data) and conversations with SMEs about reducing injuries and trainability of a foot march.

On April 22, 2014, a video teleconference (VTC) was held between USARIEM researchers and a group of nine 12B Sergeants First Class SMEs from Office of the Chief of Engineer (OCOE). They included two Soldiers from Ft. Carson, two from Joint Base Lewis-McChord and five from Ft. Leonard Wood. The SMEs were briefed on an overview of the project, the results from the physiological testing and focus groups, followed by USARIEM's plan for the criterion tasks for the 12B. The SMEs were then asked if they agreed with the criterion tasks selected, how the criterion tasks would be simulated, and if they had any concerns. The SMEs approved of the task selection and the proposed task simulation methods (See Appendix F for minutes of the VTC presented to SMEs). All of the decisions regarding selection of the criterion tasks and changes to their format were reviewed with the eight SMEs during the VTC. All of the SMEs agreed to the criterion tasks selected and the task simulation methods as described by USARIEM personnel.

## STUDY 2: METHODS

### RELIABILITY TESTING

Data were collected from May 5 to 16, 2014 at Joint Base Lewis-McChord, WA. A total of 50 active duty Soldiers (25 male, 25 female) were recruited for participation in this portion of the study. Soldiers were part of 593rd Expeditionary Sustainment Command or 3rd Stryker Brigade Combat Team, 2nd Infantry Division, and they held a number of different MOSs or (or Areas of Concentration for officers). The sample size was determined by using the sample size estimation formula of Hopkins (14) and data on repetitive lifting tasks from Pandorf (23), which indicated that 37 subjects would be needed to accurately find a difference in scores at the $p<0.05$ level.

Soldiers were briefed on all of the tasks prior to consenting. Following consent and screening, participating Soldiers were asked to complete an information sheet that contained demographics and task performance history. Anthropometrics were also collected prior to testing.

Participating Soldiers performed casualty evacuation, sandbag carry and the casualty drag four times, with each task being completed once per testing session, with at least 10 min rest between tasks. The order of testing the three tasks was randomized on day one and repeated on days two through four. Each testing session was separated by 24 to 72 hours. The foot march was performed two times, one week apart and on separate days from the rest of the tasks. All aspects of the testing (instructions, uniform, etc.) were matched as closely as possible at each testing session. All testing instructions and data sheets for Study 2 can be found in Appendices J and K, respectively.

## CRITERION TASK DESCRIPTIONS

### Casualty Evacuation from a Vehicle (Maximal Heavy Lift)

It was determined in Study 1 that heavy lifting demonstrating muscular strength was required for a number of the Combat Engineer tasks (Task 4b: remove a casualty from vehicle; Task 29: carry and emplace the MOPMS; Task 30: lift and carry rocking roller during construction of Bailey bridge; and Task 31: load and install Volcano). The most demanding of these tasks was the evacuation of a casualty through a vehicle. This task was simulated using a platform with a hole designed to simulate the hatch of a BFV and a heavy bag to simulate the casualty. A heavy bag, the same model used in Study 1, was about the same length as the average torso and head of a Soldier. The bag was placed in the hole, with the handles of the bag level with the platform (see Figure 2.3).

Prior to initiating the task, each Soldier practiced proper lifting technique using a pair of kettlebells. Then on the platform, while wearing a fighting load minus the weapon (approximately 71 lb), Soldiers squatted and grasped the handles of the heavy bag, then stood up and pulled the bag through the hole in the platform. Soldiers were required to place the heavy bag onto the platform for successful task completion. An initial load of 50 lb was used for additional familiarization and warm-up. With the successful completion of each lift, the weight of the simulated casualty was increased in 10-, 20-, or 30-lb increments. Following at least 3 min of rest at the higher loads (>80% one repetition maximum), the process was repeated until the Soldier reached volitional fatigue, failed to lift the bag during two consecutive attempts, or a maximum load of 210 lb was reached. The maximum load represented the weight of an average Soldier wearing a Vehicle Crewman Uniform. If Soldiers were not able to lift the bag following an increment of more than 20- or 30 lb, the Soldier was allowed to test on the skipped weights (i.e., 10- or 20 lb less than the failed attempt). The maximal load successfully lifted was recorded.

**Sandbag Carry (Repeated Lift and Carry)**

Repetitive lifting and carrying, requiring muscular endurance and aerobic capacity, was required for a number of the Combat Engineer tasks (Task 3: prepare a fighting position;, Task 7: load 25 mm HEI-T ammunition cans on the BFV; and Task 28: carry and emplace the H6 Cratering Charge). To capture this category of task, Soldiers lifted and carried 16 sandbags weighing 40 lb while wearing a fighting load minus the weapon (approximately 71 lb). Sandbags were carried 10 m and placed on the floor in a 4 long x 2 wide x 2 high position as quickly as possible. Time to complete the task was collected.

**Casualty Drag (Heavy Drag)**

In order to ensure a score for all participants, the casualty drag was modified from the task previously described in Study 1 (Task 4a: drag a casualty to immediate safety). Soldiers dragged the simulated casualty (approximately 270 lb) up to 15 m as fast as they could in 30 sec, while wearing a fighting load with a weapon (approximately 83 lb). If the Soldier failed to pull the casualty 15 m in 30 sec, the distance the casualty was dragged was measured. Scores were calculated as the velocity (m/s) at which the dummy was moved

**Foot March (Load Carriage)**

The ability to walk under load was needed to perform two of the previously described tasks (Task 1: conduct a foot march and Task 27: carry and emplace the APOBS). The load carriage simulation required Soldiers to complete a movement of 4 mi, while wearing the basic Soldier uniform, personal protective equipment (to include weapon), and 24-hour sustainment load (approximately 103 lb). Soldiers were instructed to complete the task as quickly as possible while walking on a supervised course. Running and the 'airborne shuffle' were not allowed. Soldiers were allowed to take breaks as needed. Soldiers were instrumented with a timing chip (SPORTident Model SIAC1, Arnstadt, Germany). Time to completion was recorded.

## STATISTICAL ANALYSES

All statistics were calculated using SPSS Version 20 (IBM Corporation, Armonk, New York). Significance was set at the $p<0.05$ level. Differences in group characteristics by sex were tested using unpaired t-tests. Descriptive statistics were calculated for each trial to characterize group performance for each task across trials. The statistical approach to determining the reliability was based on the method by Spiering et al (34) in determining reliability of other military-relevant tasks.

Two-way (sex x trial) repeated measures analysis of variance (ANOVA) was employed for each test to evaluate the presence of a learning effect between trials (2, 34). Tukey's post-hoc multiple comparison tests were applied to detect significant pairwise differences among consecutive trials. While there was evidence for a significant learning effect for a number of the tasks ($p<0.05$), this did not differ by gender, so data were collapsed by gender for all analyses. Reliability coefficients and their associated 95% confidence intervals (95% CI) were examined across trials to determine whether levels of reliability stabilize after a given number of trials. This procedure facilitated specific recommendations for numbers of practice sessions needed prior to administration of the performance tests for scoring.

Random error in the measurements was assessed as relative reliability and absolute reliability (2). Relative reliability was assessed with intraclass correlation coefficients (ICCs) while absolute reliability was assessed using Standard Error of Measurement (SEM) and 95% limits of agreement (95% LOA). ICCs were calculated using a two-way random effect, single-measure reliability model. SEMs are reported as both absolute units and as a percentage of the mean. The 95% LOA was calculated as either the 95% ratio LOA of the test-retest error if the error of the test-retest data scaled with the mean was random (as determined by a Bland-Altman plot), or as the absolute 95% LOA if the Bland-Altman plot indicated the test-retest error was homoscedastic.

## STUDY 2: RESULTS

Characteristics of the Soldiers tested are provided in Table 2.2. Soldiers were members of 19 different MOSs (including one 12B). Enlisted Soldiers ranged from E2-E7, and there were three officers (two 2nd Lieutenants and one 1st Lieutenant). Males were generally taller and heavier than the females ($p<0.01$). Both sexes had similar time in the military. Males completed more push-ups and ran faster on the APFT ($p<0.01$), but there were no difference between sexes in terms of overall AFPT scores ($p=0.99$).

### RELIABILITY TESTING

Mean scores for each of the task simulations during each test session are provided in Table 2.3. Across all trials, the average weight for the casualty evacuation was 154.0 ± 22.1 lb; average time for the sandbag carry was 2.10 ± 0.61 min; average velocity for the casualty drag was 1.07 ± 0.36 m/s; and average duration for the foot march was 75.1 ± 8.4 min. On average, males lifted more on the casualty evacuation, and were faster on the sandbag carry, casualty drag and foot march. Significant improvements in score were recorded during the second tests of the sandbag carry and casualty evacuation compared to their first attempt, indicating a possible learning effect. There was, however, no additional difference in the scores during the third and fourth trials. For the casualty drag and the foot march, there were no significant differences in individuals' scores across trials.

Reliability data are presented in Table 2.4. ICCs of the tasks across successive trials ranged from 0.79 (95% CI: 0.64-0.88) for the foot march to 0.94 (95% CI: 0.90-0.97) for the casualty evacuation. In terms of the absolute reliability tests, the SEMs ranged from 5.47% of the mean to 12% (12.47%, if the learning effect is not accounted for). The 95% LOAs were 33% for the sandbag carry time (or 0.75 min, if the learning effect between trials 1 and 2 is not taken into account), 0.35 m/s for the casualty drag, 25.7 lb for the casualty evacuation (or 32.9 lb, if the learning effect between trials 1 and 2 is not taken into account), and 11.4 min for the foot march times.

## STUDY 2: DISCUSSION

This study established the reliability of the criterion tasks to be used in the development of a testing battery for 12B Soldiers.

### TASK SELECTION

The four tasks selected represent a mix of physical requirements. Included are a long-duration load carriage, a repeated lift and carry, a heavy lift and a heavy drag. Criterion tasks used by other countries have included a similar combination of tasks. For example, the physical performance batteries developed by the United Kingdom (27) and Australia (3) both include load carriage, jerry can carry and a maximal box lift. The Australian (3) and Canadian (6) batteries also include tasks of agility, such as combat rushes. These were not included for the 12Bs, as no agility tasks were identified by the SMEs as being a key physical requirement for this MOS.

### LEARNING EFFECTS

While the casualty drag and foot march did not show indications of a learning effect, there is evidence for learning effects on the sandbag carry and casualty evacuation. There were significant improvements in sandbag carry times and casualty evacuation weights between the first and second days. There was, however, no additional improvement over any of the following days. Prior to testing of all tasks, Soldiers were given a brief familiarization and practice. For the sandbag carry, Soldiers were given a chance to lift a sandbag and determine their preferred grip. For the casualty evacuation, Soldiers were given a brief safety demonstration on proper lifting technique. They practiced on a pair of kettlebells and then a gradual increase in the weight using the heavy bag until they reached their maximum load. Additional familiarization or improvement in the test instructions could mitigate this learning effect. For implementation purposes, a practice should be provided, a wider range of acceptable scores should be accepted, or both.

### RELIABILITY

We used three measures of reliability in this study: ICC, SEM, and 95% LOA. The ICC is an indicator of relative reliability. High ICCs are indicative of a test, which is able to consistently rank participants, independent of actual score (i.e., the order of completing the task relative to their peers). As such, all of the criterion tasks had ICCs with upper bounds of their 95% CI >0.80. The test with the lowest ICC (0.79 (95% CI: 0.64-0.88)) was the foot march. The literature does not contain consistent guidelines as to what an acceptable cut-off score is for reliability. Literature values suggest that an ICC >0.75 is considered acceptable for clinical research (37). However, the authors are unaware of any legally acceptable standard.

Our two measures of absolute reliability (SEM & 95% LOA) provide an indication of the variability between repeated tests, independent of participants' rank in the sample. The SEM is a traditionally used measure of consistency that describes the general variability of the sample around its true value. It is difficult to interpret this value's meaning on the reliability of an individual's score or delineate specific cut-offs of what is acceptable reliability. A separate value is the 95% LOA, which treats the data as a population of test-retest differences (2) and calculates test-retest differences for 95% of the population. Absolute LOA are used when there would be uniform error across all scores (e.g., ± 5 lb for both a score of 100 and 200 lb), while Ratio LOA is used when the results indicate individuals with a higher score would have greater error (e.g., ± 5% of the score: ± 5 lb for a score of 100 lb, ± 10 lb for a score of 200 lb). Thus, acceptability of the 95% LOA depends on the minimal necessary precision for the test score. When using these criterion tasks to develop a predictive battery, the 95% LOAs should be taken into account as cut-scores are developed.

Reliability of the tests was comparable to those observed during reliability of other Soldiering task simulations. The learning effect of the sandbag carry and casualty evacuation are similar to those previously observed during repeated box lift and carry (23, 34) and 1RM maximal box lifts (34). The ICC of 0.79 and SEM of 5.47% for the foot march were similar to the ICC of 0.81 and SEM of 5% observed during a 3.2 kg load carriage trial (34). Likewise, the reliability of the 15-m casualty drag in the present study (ICC 0.90, SEM 11%) was similar to that observed while dragging a casualty 50 m (ICC 0.86, SEM 9%) (34). The greater reliability observed during a lift task than a carry task is consistent with the findings during a previous attempt at developing a physical employment battery for the Army (22).

**LIMITATIONS**

When interpreting the reliability of these tasks, a number of factors need to be considered. First, the sandbag carry, casualty evacuation and casualty drag tasks were performed inside of a motor pool, protected from the elements. They were also performed at approximately the same time of day with trained researchers. Thus, the data represents the reliability of these tests under those same conditions. Likewise, the foot march was completed outdoors with similar weather conditions on both days. Under differing weather locations or courses, the reliability may be less.

There are several other factors that could increase or decrease the reliability we observed. Any prior training of Soldiers, soreness or discomfort (both prior to testing or as a result of the testing) or changes in motivation could have an effect. As these factors were known a priori by research staff, steps were taken to control their impact (e.g., use of the same instructions, warm-up and practice prior to the actual task). However, it is unlikely that their influence was completely removed.

**STUDY 2: CONCLUSIONS**

The selected four criterion measure tasks reported in this chapter (casualty evacuation, casualty drag, sandbag carry and foot march) show high reliability. They have also been approved by SMEs as accurately capturing the physical demands of 12B tasks. Thus, they are appropriate for use in the development of a predictive battery to select 12B Soldiers for training.

**STUDY 2: RECOMMENDATIONS**

- The four criterion measure tasks were approved by SMEs and show generally high reliability. They are appropriate to be used for development of a predictive test; however, the absolute reliability should be considered when developing cut-scores.
- Additional familiarization and/or improvements to criterion measure task instructions should be applied to the sandbag carry and casualty evacuation tests in order to minimize any learning effect.
- The approach used to determine the reliability of Soldiering tasks may be useful for additional tasks.

**Table 2.1.** Factors Considered during Down-Selection of Criterion Measure Tasks

| Heavy Lifting Tasks | | | | | | |
|---|---|---|---|---|---|---|
| | 25 mm Barrel | Feeder Assembly | MOPMS | Bailey Bridge | BFV Cas Evac | |
| Covers Weight Range of Other Heavy Lifting Tasks | | | | X | X | |
| Common to other Combat MOS | X | X | | | X | |
| Individual Test | | X | | | | |
| Minimal Skill or Training | X | | X | X | X | |
| Minimal Equipment | | | | | X | |
| Critical to Safety and/or Mission Success | X | X | X | X | X | |

| Repeated Lift and Carry Tasks | | | | | | |
|---|---|---|---|---|---|---|
| | Volcano (Ground) (Wt.: 75 lb) | Sandbag Fill (Wt.: 35 lb) | Cratering Charge (Wt.: 40 lb) | Volcano (Truck) (Wt.: 75 lb) | Ammo Cans (Wt.: 45 lb) | Sandbag Carry (Wt.: 35 lb) |
| Greater Perceived Exertion | | X | | X | X | X |
| Greater Heart Rate | | | X | X | X | X |
| Greater Energy Cost | | | X | | X | X |
| Common to Other Combat Arms MOSs | | X | | | X | X |
| Equipment Readily Available | | X | | | X | X |
| Requires Significant Grip Strength | | | | | | X |

| Load Carriage Tasks | | | |
|---|---|---|---|
| | Foot March (Wt.: 19.5 lb) | APOBS (Wt.: 68 lb) | |
| Greater Perceived Exertion | X | X | |
| Greater Heart Rate | | X | |
| Greater Load | | X | |
| Longer Distance/Duration | X | | |
| Common to Other Combat MOSs | X | | |
| Equipment Readily Available | X | | |
| Performed More Frequently in Training & Deployment | X | | |
| Larger Range of Scores | X | | |

**Table 2.2.** Soldier Characteristics: Study 2

| | **Males (n=25)** | **Females (n=25)** | **p-value** |
|---|---|---|---|
| **Age** (years) | 24.6 ± 4.8 | 25.0 ± 4.3 | 0.80 |
| **Height** (cm) | 180.5 ± 7.3 | 165.7 ± 6.1 | <0.01 |
| **Mass** (kg) | 84.9 ± 9.8 | 67.2 ± 8.3 | <0.01 |
| | | | |
| **Time in Military** (years) | 3.4 ± 3.8 | 2.9 ± 3.0 | 0.67 |
| **Time in MOS** (years) | 2.7 ± 2.8 | 2.6 ± 2.1 | 0.91 |
| **Number Deployed** (%) | 10 (40%) | 7 (28%) | – |
| **Time Deployed** (years) *for only those who have deployed* | 0.9 ± 0.2 | 1.3 ± 0.6 | 0.04 |
| | | | |
| **Army Physical Fitness Test Score** (points) | 266.1 ± 22.8 | 266.0 ± 31.1 | 0.99 |
| **Push-up** (# / 2 min) | 67.6 ± 12.2 | 42.8 ± 12.1 | <0.01 |
| **Sit-up** (# / 2 min) | 67.8 ± 11.8 | 70.4 ± 11.4 | 0.44 |
| **Two-Mile Run Time** (min) | 14.1 ± 1.8 | 16.6 ± 1.9 | <0.01 |
| **Predicted $VO_2$max** (ml/kg/min) | 51.7 ± 5.1 | 49.1 ± 6.3 | 0.12 |

*Tasks include sandbag carry, casualty drag, and casualty evacuation.

**Table 2.3.** Performance (Mean ± SD) During Repeated Measurements of Criterion Task Simulations

| Test | | n | Trial 1 | n | Trial 2 | n | Trial 3 | n | Trial 4 |
|---|---|---|---|---|---|---|---|---|---|
| **Sandbag Carry** (min) | **M** | 25 | 1.73 ± 0.25* | 25 | 1.62 ± 0.22 | 25 | 1.68 ± 0.21 | 25 | 1.70 ± 0.23 |
| | **F** | 25 | 2.71 ± 0.80* | 25 | 2.60 ± 0.74 | 25 | 2.40 ± 0.51 | 25 | 2.42 ± 0.49 |
| **Casualty Drag** (m/s) | **M** | 25 | 1.41 ± 0.26 | 25 | 1.39 ± 0.25 | 25 | 1.32 ± 0.26 | 25 | 1.31 ± 0.24 |
| | **F** | 25 | 0.79 ± 0.25 | 25 | 0.78 ± 0.22 | 25 | 0.78 ± 0.22 | 25 | 0.78 ± 0.19 |
| **BFV Cas Evac** (lb) | **M** | 24 | 186 ± 28* | 24 | 195 ± 26 | 24 | 196 ± 26 | 25 | 198 ± 25 |
| | **F** | 25 | 106 ± 34* | 25 | 113 ± 27 | 25 | 117 ± 32 | 25 | 119 ± 31 |
| **Foot March** (min) | **M** | 25 | 70.7 ± 6.6 | 25 | 73.1 ± 5.3 | | | | |
| | **F** | 21 | 78.9 ± 10.6 | 21 | 79.1 ± 9.8 | | | | |

*Significantly different from following trial, p<0.05

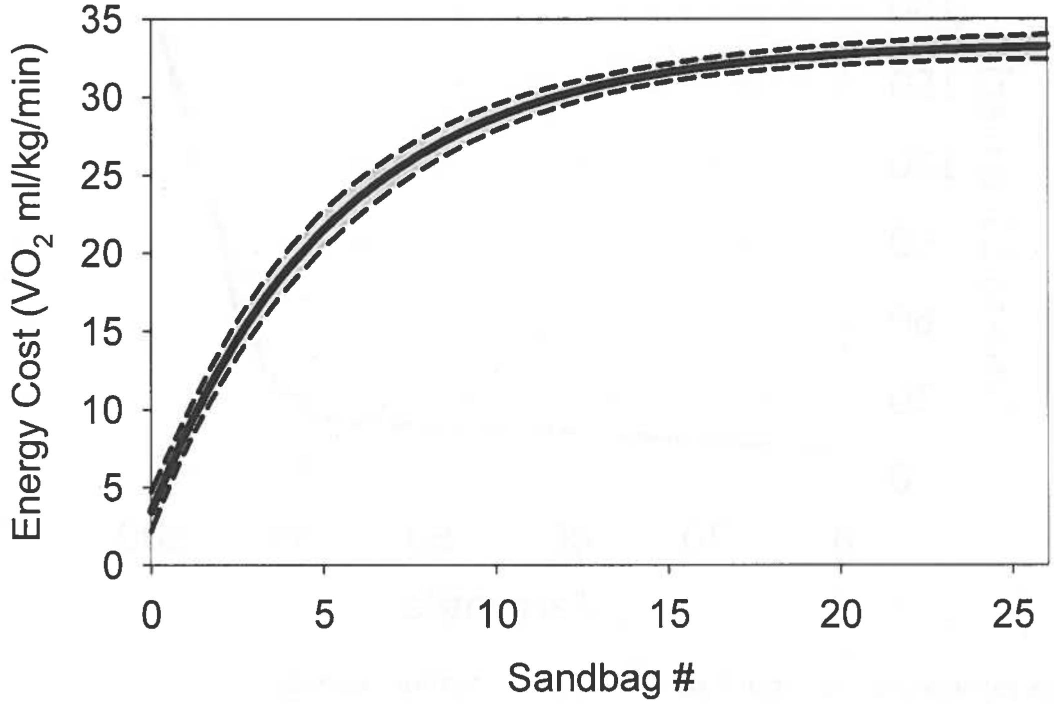
**Table 2.4.** Relative and Absolute Reliability of Criterion Task Simulations

| Test | n | Trial Comparison | Relative | Absolute | | |
|---|---|---|---|---|---|---|
| | | | ICC (2,1) [95% CI] | SEM (% of Mean) | 95% LOA | 95% Ratio LOA |
| **Sandbag Carry** (min) | 50 | 1 vs. 2 | 0.87 [0.78-0.92] | 0.27 min (12.47%) | 0.75 min | |
| | | 2 vs. 3 | 0.85 [0.75-0.91] | 0.25 min (12.00%) | | 33% |
| **Casualty Drag** (m/s) | 50 | 1 vs. 2 | 0.90 [0.83-0.94] | 0.13 m/s (11.48%) | 0.35 m/s | |
| **BFV Cas Evac** (lbs) | 49 | 1 vs. 2 | 0.94 [0.90-0.97] | 15.25 lb (10.23%) | 32.9 lb | |
| | | 2 vs. 3 | 0.96 [0.94-0.98] | 9.26 lb (5.99%) | 25.7 lb | |
| **Foot March** (min) | 46 | 1 vs. 2 | 0.79 [0.64-0.88] | 4.11 min (5.47%) | 11.4 min | |

Due to a significant learning effect for sandbag carry and casualty evacuation, 1 vs. 2 indicate reliability including learning effect, while 2 vs. 3 is without learning effect.

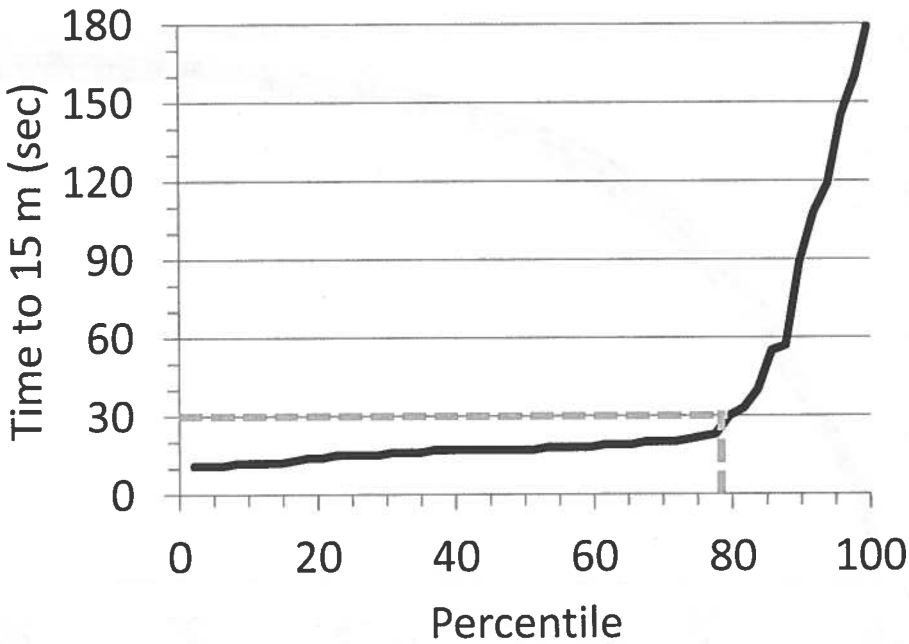
Data for Trials 3 vs. 4 not shown.

**Figure 2.1**. Fighting Position (Carry) Energy Cost over Time from Study 1



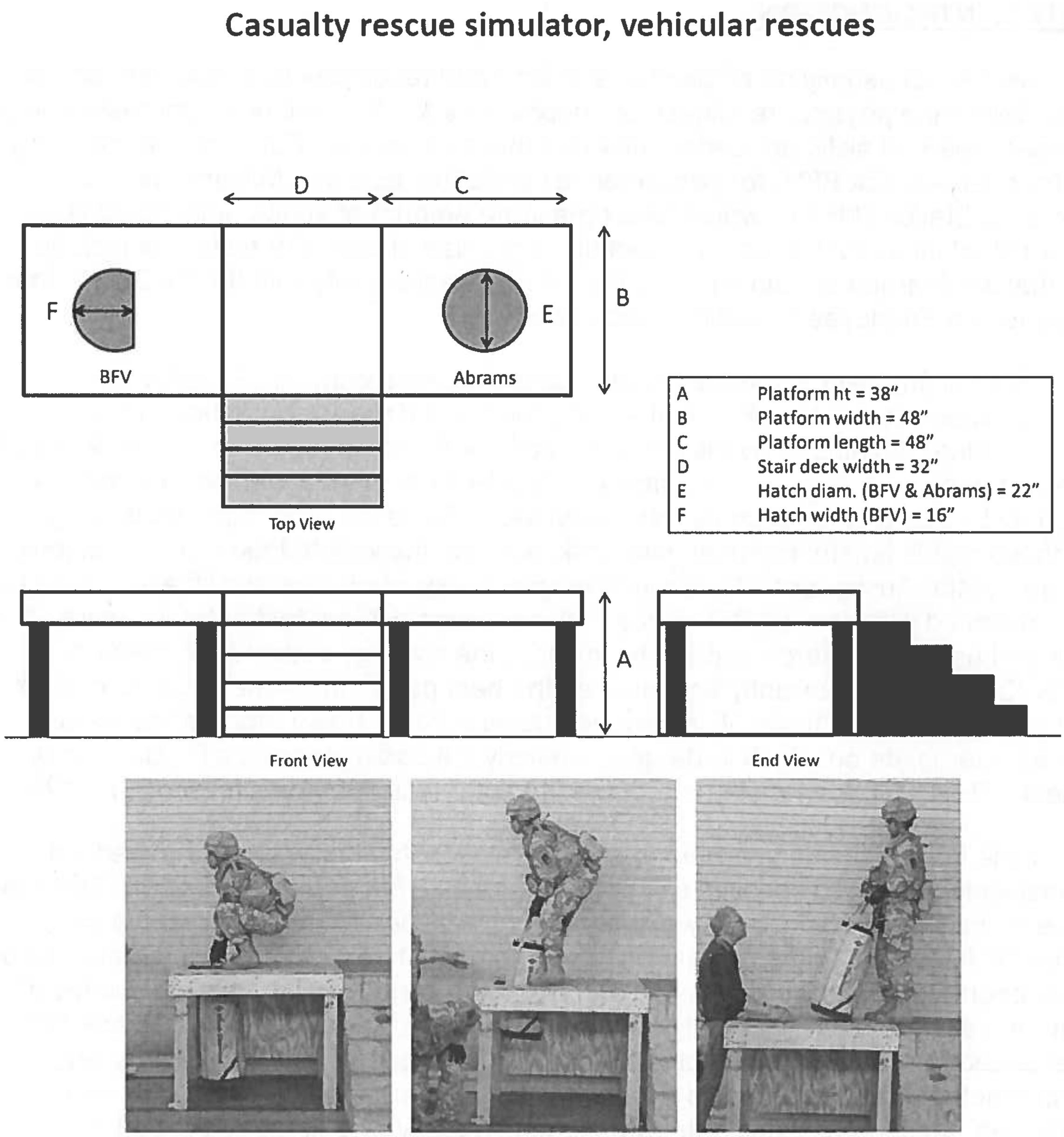

Solid line: Mean
Shaded area: 95% Confidence Interval of Mean

**Figure 2.2.** Distribution of Dummy Drag Times from Study 1




Dashed line represents maximal time allowed for criterion testing.

**Figure 2.3.** Schematic and Photos of the Casualty Evacuation Simulation



## Study 3: Predictor Test Model Development

### STUDY 3: INTRODUCTION

As it is not usually an efficient use of time and resources to employ the actual job task to determine physical readiness or success in a MOS, basic predictor tests that do not assess learned skills are better suited for these purposes. For example, devoting a BFV (or even a mock BFV) for performance prediction tests in a Military Entrance Processing Station (MEPS) would take up a large amount of space, and would likely pose a risk of injury to the recruit. In addition, the use of predictor tests that include skills that are learned in training or on the job does not comply with the EEOC Uniform Guidelines on Employee Selection Procedures (1978).

Pre-employment test batteries are becoming more common for entry into militaries across the globe. Physical employment test batteries have been (or are currently being) developed by the Armed Forces of Australia (26), Canada (6, 9) and the United Kingdom (27, 28). The physical employment batteries developed for military personnel by these other countries are provided in Table 3.1. Predictor tests range from those highly faithful to the original task, such as the weight load march and jerry can carry of the Australians (3), to much simpler tasks, such as static lift and 1.5-mi run from the United Kingdom (5, 27). These physical employment test batteries were developed using a research approach similar to the strategy outlined by Payne & Harvey (25), which is currently accepted as the best paradigm for development of pre-employment screening tests. The batteries developed for these other militaries can serve as a template on which to develop similarly validated standards for U.S. Army Soldiers. Thus, it is likely that some of the predictor tests may be similar for the 12B.

Little information is available to show a relationship between field-expedient physical tests and MOS-specific task performance of United States Soldiers. This may be due to the previous of lack of well-defined physical performance standards or criterion tasks for the Combat Arms MOSs. Prior work has shown that the combination of anthropometrics, body composition and isometric upright pull may be predictive of performance in the most physically demanding MOS; however, these tests were not implemented (31, 35). Furthermore, these predictive models included gender and anthropometric data, which would no longer be considered legally-defensible as pre-employment measures. Thus, the purpose of this study was to identify a battery of reliable, field-expedient physical tests to predict criterion task performance for the 12B MOS.

### STUDY 3: METHODS

Data were collected from July 9 to18, 2014 at Ft. Hood, TX. A total of 147 active duty Soldiers (104 male, 43 female) were recruited for participation in this portion of the study. Eight Soldiers (seven male, one female) did not complete all components of the testing, and one male Soldier's data was dropped due to low scores (lower than two SD below the mean) and non-compliance with the instructions provided by the investigators. Soldiers were of the 36th Engineer Brigade. All male Soldiers held the

12B Combat Engineer MOS, while the female Soldiers were recruited from any MOS or AOC.

Soldiers were briefed on all of the tasks prior to consenting. Following consent and screening, participating Soldiers were asked to complete an information sheet that contained demographics and task performance history. Anthropometrics were also collected prior to testing.

Sample size estimates were run using SamplePower 3.0.1 (IBM Corp, Armonk, New York). For a single predictor test, 55 subjects will be sufficient for 80% power to detect significance of simple regressions with a moderate effect size ($R^2 = 0.13$) at an alpha of 0.05 (8). To establish the ability of the predictive tests to determine performance in the criterion tasks, a sample size of 90 subjects allows for 80% power to detect statistical significance for predictive tests, which includes a five-test battery regression model at a moderate effect size ($R^2 = 0.13$, (8)).

## TESTING OVERVIEW

Testing consisted of the four criterion tasks and 12 predictor tests. The four criterion tasks were the foot march, casualty drag, casualty evacuation and sandbag carry. The 12 predictive tests were the loaded step test, beep test, Illinois agility test, standing long jump, handgrip, 38-cm upright pull, medicine ball put, isometric biceps curl, 1-min sit-up, 1-min push-up, 300 m sprint and arm ergometer test.

Soldiers were placed in one of four squads and completed all testing as part of that squad. Testing was separated into three sessions, and Soldiers had at least 24 hours between testing sessions. The first session included only the foot march; the second session included 11 of the 12 predictive tests (all except the loaded step test); and final testing session included the casualty drag, casualty evacuation, sandbag carry and the loaded step test.

## TESTING PROCEDURES

All four of the criterion tasks were administered as described in Study 2 (See previous chapter). The only modification was the addition of a rubber flooring (4' x 6' x 3/4" Interlocking Diamond Plate Tiles, Kodiak Sports, Plano, TX) for the casualty drag. This allowed for a standardized surface for testing, which would therefore standardize the resistance of the dummy. All testing instructions and data sheets for Study 3 can be found in Appendices L and M, respectively. The predictor tests were administered as follows:

### Loaded Step Test

Soldiers stepped up and down on a 12" step in time to a metronome sounding at a rate of 120 bpm. Four counts were used to complete a full up and down motion (up, up, down, down) for a stepping rate of 30 steps per minute. A heart rate monitor and a fighting load of 80 lb were worn. Soldiers stepped up and down at 30 cycles/min for 5 min or until they failed to keep the pace for two consecutive up-and-down motions. Endurance time (min), heart rate and RPE were recorded (19).

**Beep Test**

Soldiers continuously ran between two lines 20 m apart in time to recorded beeps. Soldiers began standing behind one of the lines facing the second line. When instructed by a recording, they began running at a slow pace. Soldiers continued running between the two lines, placing at least one foot over the opposite line and turning when signaled by the recorded beeps. After each minute, a tone indicated an increase in speed, and the pace of the beeps became faster. If the line was not reached before the beep sounded, the Soldier was given a warning and continued to run to the line, turned and tried to catch up with the pace within two more 'beeps'. The test was stopped when the Soldier failed to reach the line for two consecutive beeps after a warning. The total number of shuttles completed was recorded (20).

**Illinois Agility Test (See Figure 3.1)**

The length of the course was 10 m and the width (distance between the start and finish points) was 5 m. Four cones were used to mark the start, finish and the two turning points. Another four cones were placed down the center an equal distance apart. Each cone in the center was spaced 3.3 m apart. Soldiers began by lying prone (head to the start line) with their hands by their shoulders. On the 'go' command the stopwatch was started, and the Soldier got up as quickly as possible and ran around the course in the direction indicated, without knocking the cones. Time to complete the course was recorded (12).

**Standing Long Jump**

Soldiers stood behind a line marked on the ground with feet slightly apart. A two foot take-off and landing was used, with swinging of the arms and bending of the knees to provide forward drive. Soldiers attempted to jump as far as possible, landing on both feet without falling backwards. Three attempts were allowed. The two furthest distances jumped (cm) were averaged (17).

**Handgrip**

Soldiers held a handgrip dynamometer (Jamar Plus+, Sammons Preston, Bolingbrook, IL) in their hand, with the elbow at a right angle and at the side of the body. The handle of the dynamometer was adjusted such that the base rested on first metacarpal (heel of palm), while the handle rested on middle of four fingers. When ready, Soldiers squeezed the dynamometer with maximum isometric effort for about 3 to 5 sec. No other body movements were allowed. Three trials were given for each hand. The highest two trials (kg) on each side were averaged (1).

**Upright Pull**

The Soldier assumed a squatting position with their buttocks against a wall, head and shoulders up and arms extended, while grasping the handle of the dynamometer in a mixed grip. On command, the Soldier pushed down by extending the knees and pulled up by extending the hips to exert maximum force on the handle. The peak force produced was recorded. Soldiers were given a minimum of three trials, with about 1-min rest in between each trial. If there was more than a 10% difference in the three scores, they were given up to two additional trials. The highest two trials within 10% of each other were averaged to determine an overall score (16).

**Medicine Ball Put**

Soldiers sat with their back firmly against a chair placed against a wall, while holding a 2-kg medicine ball with both hands. On command, the Soldier touched his/her chest with the ball and pushed it as far forward as possible. The distance between the landing point and the front of the chair was measured. Soldiers were given two practices and three attempts. The average of two furthest distances (cm) of the three attempts was used for analysis (13).

**Isometric Biceps Curl**

Soldiers stood on a wooden platform holding onto a bar with palms facing up, elbows at right angle and forearms parallel to the floor. The bar was attached to a chain attached to the platform, and an inline dynamometer with a force display recorded force production. On command, they pulled upward on the bar maximally for 3 to 5 sec. The highest two of three trials were averaged for record (30).

**One Minute Sit-up**

The sit-up test used the same rules as the APFT (36), with the exception that the test was only one minute in duration. Briefly, Soldiers began by lying on their back with the knees bent at a 90° angle. Their feet could be up to 12 in apart and were held down by a second individual. Soldiers' fingers were interlocked behind their head. On the command 'go,' the sit-up was started by raising the upper-body forward to or beyond the vertical position (meaning that the base of the neck is above the base of the spine), and then the body was lowered until the bottom of the shoulder blades and the backs of the hands touched the ground. Soldiers performed as many correct sit-ups as possible in 1 min.

**One Minute Push-up**

The push-up test used the same rules as the APFT (36), with the exception that the test was only 1 min in duration. Briefly, Soldiers began with their arms straight, hands a comfortable distance apart, and body straight. Soldiers' feet could be up to 12 in apart. On the command 'go,' the push-up was started by bending elbows and lowering the body until the upper arms were at least parallel to the ground. Soldiers then returned to the starting position. Soldiers performed as many correct push-ups as possible in 1 min.

**300 Meter Sprint**

Soldiers ran 300 m around a track as quickly as possible. Prior to testing, Soldiers were allowed time to warm up and stretch. Times (min) were collected using a stopwatch.

**2-Minute Arm Ergometer**

Soldiers cranked an arm ergometer (Model 881E, Monark AB, Varberg, Sweden) as fast as possible for 2 min. The workload was fixed at 50 watts. Soldiers were in a kneeling position facing the arm ergometer with the center crank adjusted to shoulder height. The total number of revolutions was recorded (10, 11).

## STATISTICAL ANALYSES

Unpaired T-tests were used to compare group characteristics by sex. Descriptive statistics were calculated for each test and criterion measure to characterize each sex, as well as group performance on each test. Correlation coefficients were computed to quantify strength of association among test variables and between test and criterion measures. Criterion measure scores were converted to z-scores in order to create a common metric for all criterion tasks. The conversion to z-scores allows the criterion measures to be combined into one measure of performance. Z-scores for the sandbag carry and foot march were inverted so that faster, better scores corresponded to higher z-scores. For each individual, the z-scores for all criterion tasks of their MOS were summed to create a total criterion task performance score. Multiple linear regression models were developed using forward stepwise procedures to produce equations predicting the total criterion task score, with each model using the field-expedient physical performance tests as predictor variables. Several models were developed to provide several options for courses of action depending on the availability of funding and equipment. For each model, secondary analyses were performed in order to identify predictive ability of the model for each individual criterion task.

## STUDY 3: RESULTS

Characteristics of the Soldiers tested are provided in Table 3.2. While all of the men were 12Bs, female Soldiers were members of 26 different MOSs. Enlisted Soldiers ranged from E1 to E7, and there were three female officers (1-O1, 1-O2, 1-O3) and one female warrant officer (WO1). Men were taller and heavier than the females ($p<0.01$). There were no differences in time in military or MOS. Women had a significantly higher overall mean APFT score (<0.01); however, they performed significantly fewer push-ups and slower on the 2-mi run time compared to the men.

## TESTING PERFORMANCE

Summaries and distributions of raw criterion task scores are provided in Table 3.3, and z-transformed criterion task scores and summed criterion z-scores are provided in Table 3.4. For the predictor tests, summaries and distributions are shown in Table 3.5.

## PREDICTION MODELS

Bivariate correlation among the criterion tasks and predictor tests are provided in Table 3.6. The only non-significant correlations were among the sit-ups with the sandbag carry and sit-ups with the casualty evacuation criterion tasks. Four performance predictor models (Table 3.7) were developed using data from 138 Soldiers for whom complete datasets were available:

- The first model included all of the predictor tests. In this model, the arm ergometer, upright pull, 300 m sprint and medicine ball put came out as significant predictors (Full Model Adjusted $R^2$=0.82, $p<0.01$).
- A second model omitted the arm ergometer, as the cost of the device may be prohibitive. The significant predictors in this model were the beep test, upright pull, 300 m sprint and medicine ball put (Full Model Adjusted $R^2$=0.79, $p<0.01$).
- The third model did not use any calibrated equipment and omitted any equipment that would not be easily purchased at a sporting goods store (as requested by Mr. Brinkley, G3/5/7 TRADOC). This model thus excluded the arm ergometer, handgrip, upright pull and biceps curl tests as potential covariates. The resulting model consisted of the medicine ball put, 300 m sprint and 1-min push-up (Full Model Adjusted $R^2$=0.75, $p<0.01$).
- The final model consisted of tests that only required a stopwatch and tape measure. This model excluded the arm ergometer, handgrip, upright pull, biceps curl and medicine ball tests as potential covariates. For this model, the standing long jump, 300 m sprint, 1-min push-up and 1-min sit-up tests were the significant predictors (Full Model Adjusted $R^2$=0.62, $p<0.01$).

Correlations of the four models with the individual criterion tasks ranged from r=0.63-0.88, with the foot march having the lowest correlations (r=0.67-0.63), and the casualty drag (r=0.88-0.73) and evacuation (r=0.86-0.78) having the highest. Notably, all of the predictors for each model were significantly predictive of at least one of the individual criterion tasks. Summaries of all of the models, as well as their correlations with individual criterion tasks are provided in Table 3.8. Additional statistics on the models are provided in Appendix N.

## STUDY 3: DISCUSSION

This study validated the ability of 12 basic physical tests to predict 12B physical job performance. From those tests, a collection of four potential testing models were constructed to predict physical performance on the 12B criterion tasks. All four of the models are highly predictive of 12B physical job performance with $R^2 \geq 0.60$.

## INDIVIDUAL PREDICTORS

Of the 12 predictor tests, 11 were significantly predictive of all criterion tasks. The only exception was the sit-up test. One possible explanation is that, while sit-up performance may be correlated with overall fitness (7), it is not a very specific measure of any one aspect of fitness relevant to the selected criterion tasks. Sit-up testing primarily assesses endurance of the abdominal (core) musculature. Of the criterion tasks, core endurance may contribute to task performance, such as aiding in the ability to carry a load for long distances, but is unlikely to be a key limiting factor.

## PREDICTION MODELS

Four possible outcome models were provided based on four logistical requirements. All four of the models showed significant predictive power and were much better than a model based solely on APFT performance ($R^2$=0.39, data not shown). While not exactly the same, most of the models capture similar fitness requirements to those developed by other countries (Table 3.9).

The first model, which included all eight tests included in the regression analyses, has the highest $R^2$ (0.82). This test battery includes the arm ergometer, upright pull, 300 m sprint and medicine ball put. Notably, this model consists of tests that capture four different aspects of fitness. The arm ergometer tests upper body endurance; the medicine ball put tests upper body power; the upright pull measures lower body strength; and the 300 m sprint captures some aspects of lower body power and endurance. While this model is optimal from a predictive viewpoint, the associated test equipment can be costly and needs to be periodically calibrated and maintained. The arm ergometer is space efficient and accurate and may be feasible for use in a limited number of test sites; however, purchasing and maintaining the equipment for a large number of sites may not be deemed possible.

The second model includes three of the same tests as the first model (300 m sprint, medicine ball put and upright pull). With the arm ergometer excluded from this regression, the beep test significantly entered the model, which captures whole body aerobic capacity. This second testing battery maintains much of the predictive power of the first model (R2=0.79), without the expense of the arm ergometer. While the beep test does not require a lot of equipment, it does demand a large area (over 20 m in length). In addition, an upright pull dynamometer may be costly and would still require occasional calibration and replacement costs.

The third model eliminates the need for any calibrated equipment that is not readily purchased at a sporting goods store. This model resulted in a test battery consisting of three tests: the medicine ball put, 300 m sprint and 1-min push-ups. The 1-min push-up test captures upper body endurance. Although the $R^2$ for this model (0.75) is lower than models 1 and 2, this third model is still highly predictive of 12B physical performance. This set of tests requires only a medicine ball, tape measure, and stopwatch. This makes it a much more inexpensive option to implement.

The final model eliminates the need to purchase any equipment other than a stopwatch and a tape measure. This model produced a test battery, including the standing broad jump (a measure of lower-body power), 300 m sprint, 1-min push-up and 1-min sit-ups (a measure of core endurance). While this test battery is the least expensive and significantly related to 12B physical job performance, it also has the lowest predictive value of any of the models developed and therefore the greatest potential of misclassify those who pass or fail the test. (See further discussion of misclassification aspects below.)

**ESTABLISHMENT OF CUT POINTS AND FOLLOW-UP**

Once a predictive model is selected, the next step will be the identification of acceptable cutoffs for each predictor test. First, for each of the criterion tasks, a minimum acceptable score for the safe and efficient performance of each criterion task simulation will need to be determined. The determination of this score should include several elements including requirements of the job task and trainability of an incoming recruit. Requirements of the job can be established by TRADOC based on the needs and training of the Army. Because these predictive tests are to be administered to incoming recruits and not Soldiers who currently retain the MOS, it will be necessary to account for the ability to train an incoming recruit in One Station Unit Training (OSUT). Improvements of up to 6% in $VO_2$peak and lower-body strength have been shown following eight weeks of Basic Combat Training (BCT) (32).

It will then be possible to identify cut-scores for the predictive tests. Because no model is perfect, there will be error in the predictions. Thus, it may be necessary to adjust the cut-scores to optimize the number of individuals who are incorrectly identified as passing or failing the test. A higher cut-off will decrease the number of false positives (i.e., people who pass the test battery but would not be successful in the MOS), but it will also increase the number of false negatives (i.e., people who fail the test battery but would be successful in the MOS). Along with values for the cut-scores, the type of cut-offs need to be established as well. For testing batteries such as the ones presented in this report, there are three main types of cut scores: multiple hurdle, compensatory and hybrid (11). For a multiple hurdle test, a potential recruit would need to reach a minimum score on each test to pass the test (e.g., scoring 60/100 points on all four tests). With the compensatory model, recruits must reach a total score based on the combination of the test scores. The compensatory model allows for an individual to make up for a poor performance on one test with a better performance on another (e.g., requiring a total score of 240 points on four tests scored out of 100 points). The hybrid combines these two approaches, where there is a minimal acceptable score on each test, but the total score must be greater than the sum of the acceptable scores (e.g., scoring 50/100 points on all four tests and requiring a total score of 240).

After implementation of this test battery, long-term observation of Combat Engineer recruits is absolutely essential for the full validation of the model. The test should be administered to all Soldiers entering the Combat Engineer MOS, and these Soldiers should be tracked throughout their first term of enlistment. The information recorded should include success/failure and time in Initial Military Training, performance on the 12 critical tasks, injuries, attrition from the Army, Enlisted Evaluation Reports and reclassification to other MOSs. The entry standards for the test battery must be adjusted based on these data. This will require creation of an on-line database, standardized measurement and recording of these data and periodic longitudinal analyses of the data.

## LIMITATIONS

It should be noted that the four models developed are discrete testing batteries. It is not possible to simply swap one test out for another. While any given predictor has the core fitness domain (such as upper-body endurance) that it captures, each test also has unique features. For example, push-ups and the arm-ergometer both capture upper body endurance, but due to their differing methodology, if one was substituted for the other, the result may not be an optimal test battery.

The models developed all depend on one key caveat: the correct selection of the criterion tasks. The job performance score being predicted is based on those four criterion tasks. While our research indicates that these are the appropriate criterion tasks, and these four tasks capture many aspects of the physically demanding tasks of a 12B, it is possible that there are critical aspects of other tasks not being captured. It may be necessary to revise the model if additional physically demanding tasks are identified, or if the task demands change due to changes in equipment.

## STUDY 3: CONCLUSIONS

The present study developed four models in order to effectively predict performance on MOS-specific criterion tasks that were identified in Studies 1 and 2. The strongest model included the arm ergometer, upright pull, 300 m sprint and medicine ball put as predictor tests. Other models are provided to serve as sufficient alternatives based on cost, feasibility and equipment availability.

## STUDY 3: RECOMMENDATIONS

- The Army should select one of the four predictor test models that best meets their logistical needs and constraints. Consideration should be given to the components of physical fitness assessed by the model.
- In order to establish cut-points, minimal acceptable scores on the criterion tasks need to be established, which can then be used to identify critical scores on the predictor tests.
- Follow-up studies should confirm the validity of this model in a separate group of Soldiers.
- The predictive test model should be administered through a series of Soldiers entering BCT/AIT and continued through the early years of their career in order to establish the predictive accuracy of the model. Longitudinal follow-ups should be considered on a routine basis to ensure the continued acceptability of the prediction model.

**Table 3.1.** Physical Pre-Employment Test Batteries Developed by the Armed Forces of Australia, Canada, and the United Kingdom

| Country | Soldiering task tests | Field-expedient tests |
|---|---|---|
| Australia (3) | All Corps<br>• Load Carriage<br>• Combat Rushes<br>• Jerry Can Carry<br>• Heavy Equipment Lift<br><br>Artillery<br>• All Corps + Moving Ammunition for a M777A2 Conducting a 10 Round Fire for Effect<br><br>Infantry<br>• All Corps + Casualty Drag | All Corps<br>• Weight Load March<br>• Fire and Movement<br>• Jerry Can Carry<br>• Box Lift and Place<br><br>Artillery<br>• All Corps + Repeatedly Lift and Carry 10 m an Inert Artillery Round<br><br>Infantry<br>• All Corps + Simulated Casualty Drag |
| Canada (6, 9, 29) | • Escape to Cover<br>• Sandbag Fortification<br>• Pickets and Wire Carry<br>• Picking and Digging<br>• Vehicle Extrication<br>• Stretcher Carry | • Sandbag Lift<br>• Intermittent Loaded Shuttles<br>• 20 m Rushes<br>• Sandbag Drag |
| United Kingdom (5, 27, 28) | • Jerry Can Carry<br>• Load Carriage<br>• Single Ammo Box Lift | • 1.5-mi Run/Beep Test<br>• Jerry Can Carry<br>• Static Lift<br>• Sit-Up<br>• Push-Up |

**Table 3.2.** Soldier Characteristics: Study 3

| | Males (n=96) | Females (n=42) | p-value |
|---|---|---|---|
| **Age** (years) | 24.0 ± 4.2 | 24.3 ± 4.4 | 0.73 |
| **Height** (cm) | 178.4 ± 6.5 | 164.8 ± 7.7 | <0.01 |
| **Mass** (kg) | 84.3 ± 12.9 | 66.7 ± 8.7 | <0.01 |
| **Time in Military** (years) | 3.1 ± 2.9 | 3.3 ± 2.5 | 0.71 |
| **Time in MOS** (years) | 3.1 ± 2.8 | 2.5 ± 2.1 | 0.29 |
| **Number Deployed** (%) | 78 (81%) | 15 (36%) | – |
| **Time Deployed** (years) *for only those who have deployed* | 1.2 ± 0.8 | 0.8 ± 0.7 | 0.12 |
| **Army Physical Fitness Test Score** (points) | 256.1 ± 27.6 | 270.8 ± 23.9 | <0.01 |
| **Push-ups** (# / 2 min) | 65.3 ± 11.5 | 45.3 ± 11.5 | <0.01 |
| **Sit-ups** (# / 2 min) | 69.2 ± 10.7 | 70.8 ± 10.3 | 0.41 |
| **2-Mile Run Time** (min) | 14.5 ± 1.3 | 16.3 ± 1.1 | <0.01 |
| **Predicted $VO_2$max** (ml/kg/min) | 50.8 ± 5.5 | 50.2 ± 4.1 | 0.53 |

**Table 3.3.** Criterion Task Performance as Raw Scores

| | | Foot March Time (min) [a] | | | Sandbag Carry Time (min) [a] | | | BFV Cas Evac Weight (lb) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | C | M | F | C | M | F | C |
| **n** | | 96 | 42 | 138 | 96 | 42 | 138 | 96 | 42 | 138 |
| **Mean** | | 75.72 | 90.05 | 80.08 | 1.71 | 2.65 | 1.99 | 202 | 124 | 178 |
| **SD** | | 9.09 | 14.56 | 12.83 | 0.33 | 0.64 | 0.62 | 20 | 28 | 43 |
| **Minimum** | | 107.83 | 137.65 | 137.65 | 3.08 | 4.43 | 4.43 | 120 | 50 | 50 |
| **Percentiles** | **5** | 94.37 | 117.17 | 106.40 | 2.27 | 4.08 | 3.20 | 150 | 90 | 100 |
| | **10** | 88.38 | 109.68 | 97.88 | 2.10 | 3.48 | 2.92 | 170 | 90 | 110 |
| | **25** | 79.96 | 97.88 | 85.37 | 1.87 | 2.98 | 2.25 | 210 | 100 | 140 |
| | **50** | 73.75 | 87.25 | 77.32 | 1.66 | 2.47 | 1.83 | 210 | 120 | 210 |
| | **75** | 69.48 | 78.30 | 71.17 | 1.48 | 2.15 | 1.58 | 210 | 140 | 210 |
| | **90** | 66.00 | 76.87 | 66.58 | 1.33 | 2.00 | 1.40 | 210 | 160 | 210 |
| | **95** | 65.23 | 75.38 | 65.75 | 1.23 | 1.92 | 1.27 | 210 | 170 | 210 |
| **Maximum** | | 62.47 | 69.85 | 62.47 | 1.03 | 1.78 | 1.03 | 210 | 190 | 210 |

| | | Casualty Drag Speed (m/s) | | |
|---|---|---|---|---|
| | | M | F | C |
| **n** | | 96 | 42 | 138 |
| **Mean** | | 1.16 | 0.45 | 0.94 |
| **SD** | | 0.36 | 0.22 | 0.46 |
| **Minimum** | | 0.26 | 0.04 | 0.04 |
| **Percentiles** | **5** | 0.57 | 0.15 | 0.22 |
| | **10** | 0.68 | 0.18 | 0.33 |
| | **25** | 0.91 | 0.29 | 0.53 |
| | **50** | 1.18 | 0.45 | 0.93 |
| | **75** | 1.44 | 0.51 | 1.31 |
| | **90** | 1.59 | 0.70 | 1.53 |
| | **95** | 1.74 | 0.90 | 1.61 |
| **Maximum** | | 2.04 | 1.15 | 2.04 |

[a] Scores inverted so faster times = higher percentile

**Table 3.4.** Criterion Task Performance as Z-Scores

| | | Foot March Time[a] | | | Sandbag Carry Time[a] | | | BFV Cas Evac Weight | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | C | M | F | C | M | F | C |
| n | | 96 | 42 | 138 | 96 | 42 | 138 | 96 | 42 | 138 |
| Mean | | 0.34 | -0.78 | 0.00 | 0.48 | -1.03 | 0.02 | 0.57 | -1.26 | 0.02 |
| SD | | 0.71 | 1.14 | 1.00 | 0.52 | 1.03 | 1.00 | 0.46 | 0.67 | 1.00 |
| Minimum | | -2.17 | -4.50 | -4.50 | -1.72 | -3.88 | -3.88 | -1.34 | -2.98 | -2.98 |
| Percentiles | 5 | -1.11 | -2.90 | -2.05 | -0.41 | -3.32 | -1.91 | -0.64 | -2.04 | -1.81 |
| | 10 | -0.65 | -2.31 | -1.39 | -0.15 | -2.36 | -1.46 | -0.17 | -2.04 | -1.58 |
| | 25 | 0.01 | -1.39 | -0.41 | 0.23 | -1.56 | -0.39 | 0.77 | -1.81 | -0.87 |
| | 50 | 0.50 | -0.56 | 0.22 | 0.56 | -0.73 | 0.28 | 0.77 | -1.34 | 0.77 |
| | 75 | 0.83 | 0.14 | 0.70 | 0.84 | -0.23 | 0.68 | 0.77 | -0.87 | 0.77 |
| | 90 | 1.10 | 0.25 | 1.06 | 1.08 | 0.01 | 0.97 | 0.77 | -0.40 | 0.77 |
| | 95 | 1.16 | 0.37 | 1.12 | 1.24 | 0.15 | 1.19 | 0.77 | -0.17 | 0.77 |
| Maximum | | 1.38 | 0.80 | 1.38 | 1.56 | 0.36 | 1.56 | 0.77 | 0.30 | 0.77 |

| | | Casualty Drag Speed | | | Summed Z-sum | | |
|---|---|---|---|---|---|---|---|
| | | M | F | C | M | F | C |
| n | | 96 | 42 | 138 | 96 | 42 | 138 |
| Mean | | 0.49 | -1.05 | 0.02 | 1.89 | -4.11 | 0.07 |
| SD | | 0.77 | 0.49 | 1.00 | 1.88 | 2.33 | 3.43 |
| Minimum | | -1.46 | -1.94 | -1.94 | -6.37 | -8.36 | -8.36 |
| Percentiles | 5 | -0.79 | -1.70 | -1.55 | -1.45 | -8.06 | -7.07 |
| | 10 | -0.54 | -1.64 | -1.31 | -0.36 | -7.55 | -5.39 |
| | 25 | -0.05 | -1.40 | -0.87 | 0.73 | -6.00 | -2.18 |
| | 50 | 0.52 | -1.04 | -0.02 | 2.15 | -3.74 | 1.09 |
| | 75 | 1.10 | -0.91 | 0.81 | 3.23 | -2.26 | 2.64 |
| | 90 | 1.42 | -0.50 | 1.30 | 3.88 | -1.36 | 3.71 |
| | 95 | 1.74 | -0.06 | 1.46 | 4.54 | -1.05 | 4.27 |
| Maximum | | 2.39 | 0.47 | 2.39 | 5.28 | 1.03 | 5.28 |

[a] Z-Scores inverted so faster (shorter) times = positive Z-score

**Table 3.5.** Predictor Test Performance

| | | Step Test Duration (min) [a] | | | Beep Test Shuttles (#) | | | 1-Minute Sit-up (#) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | C | M | F | C | M | F | C |
| **n** | | 94 | 41 | 135 | 96 | 42 | 138 | 96 | 42 | 138 |
| **Mean** | | 3.40 | 1.97 | 2.97 | 66 | 46 | 60 | 44 | 44 | 44 |
| **SD** | | 1.32 | .99 | 1.40 | 18 | 12 | 19 | 6 | 5 | 6 |
| **Minimum** | | 0.92 | 0.82 | 0.82 | 32 | 30 | 30 | 27 | 31 | 27 |
| **Percentiles** | **5** | 1.48 | 1.00 | 1.10 | 40 | 32 | 34 | 33 | 35 | 33 |
| | **10** | 1.68 | 1.08 | 1.35 | 42 | 34 | 38 | 36 | 36 | 36 |
| | **25** | 2.27 | 1.30 | 1.75 | 52 | 37 | 44 | 40 | 40 | 40 |
| | **50** | 3.26 | 1.75 | 2.60 | 66 | 44 | 57 | 44 | 44 | 44 |
| | **75** | 5.00 | 2.23 | 4.30 | 78 | 49 | 73 | 49 | 48 | 48 |
| | **90** | 5.00 | 3.15 | 5.00 | 91 | 62 | 88 | 52 | 49 | 52 |
| | **95** | 5.00 | 4.30 | 5.00 | 97 | 70 | 93 | 55 | 52 | 54 |
| **Maximum** | | 5.00 | 5.00 | 5.00 | 113 | 92 | 113 | 56 | 54 | 56 |
| | | **1-Minute Push-up** (#) | | | **Arm Ergometer** (#) | | | **Standing Long Jump** (cm) | | |
| | | M | F | C | M | F | C | M | F | C |
| **n** | | 96 | 42 | 138 | 96 | 42 | 138 | 96 | 42 | 138 |
| **Mean** | | 48 | 32 | 43 | 256 | 184 | 234 | 211.1 | 162.1 | 196.2 |
| **SD** | | 10 | 8 | 12 | 30 | 23 | 43 | 23.2 | 15.7 | 31.0 |
| **Minimum** | | 25 | 18 | 18 | 139 | 143 | 139 | 152.5 | 135.0 | 135.0 |
| **Percentiles** | **5** | 34 | 21 | 25 | 217 | 151 | 158 | 175.0 | 139.0 | 144.5 |
| | **10** | 36 | 23 | 29 | 222 | 157 | 171 | 181.5 | 142.5 | 153.5 |
| | **25** | 42 | 27 | 35 | 240 | 168 | 195 | 195.5 | 151.0 | 172.0 |
| | **50** | 47 | 32 | 42 | 257 | 184 | 241 | 211.0 | 159.5 | 199.3 |
| | **75** | 54 | 36 | 50 | 273 | 196 | 266 | 225.8 | 176.0 | 215.5 |
| | **90** | 62 | 42 | 58 | 292 | 210 | 286 | 241.5 | 182.5 | 235.5 |
| | **95** | 65 | 48 | 65 | 307 | 218 | 303 | 251.0 | 192.5 | 246.5 |
| **Maximum** | | 76 | 53 | 76 | 326 | 252 | 326 | 282.5 | 195.0 | 282.5 |
| | | **300 m Sprint** (min) [a] | | | **Handgrip Sum** (lbs) | | | **Medicine Ball Put** (cm) | | |
| | | M | F | C | M | F | C | M | F | C |
| **n** | | 96 | 42 | 138 | 96 | 42 | 138 | 96 | 42 | 138 |
| **Mean** | | 0.89 | 1.05 | 0.94 | 203.5 | 133.1 | 182.1 | 627.4 | 438.2 | 569.9 |
| **SD** | | 0.09 | 0.07 | 0.11 | 32.6 | 24.4 | 44.4 | 81.8 | 44.6 | 113.4 |
| **Minimum** | | 1.20 | 1.25 | 1.25 | 130.5 | 91.2 | 91.2 | 451.5 | 356.2 | 356.2 |
| **Percentiles** | **5** | 1.03 | 1.15 | 1.13 | 151.6 | 100.4 | 107.7 | 499.2 | 364.3 | 385.7 |
| | **10** | 1.00 | 1.13 | 1.10 | 155.6 | 102.3 | 122.5 | 526.4 | 378.7 | 419.3 |
| | **25** | 0.93 | 1.10 | 1.02 | 185.1 | 114.7 | 147.3 | 571.2 | 412.7 | 473.5 |
| | **50** | 0.88 | 1.05 | 0.93 | 206.9 | 133.0 | 187.1 | 627.7 | 437.4 | 579.0 |
| | **75** | 0.83 | 1.00 | 0.85 | 222.0 | 149.3 | 214.1 | 678.7 | 463.4 | 647.2 |
| | **90** | 0.78 | 0.97 | 0.80 | 252.0 | 161.0 | 240.6 | 734.6 | 493.7 | 718.0 |
| | **95** | 0.77 | 0.93 | 0.77 | 261.0 | 170.8 | 254.6 | 765.8 | 521.3 | 745.8 |
| **Maximum** | | 0.68 | 0.87 | 0.68 | 275.2 | 208.2 | 275.2 | 866.7 | 543.2 | 866.7 |

[a] Scores inverted so faster (shorter) times = higher percentile

**Table 3.5.** Predictor Test Performance (continued)

| | | Illinois Agility Test (min) [a] | | | Upright Pull (lb) | | | Biceps Curl (lb) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | C | M | F | C | M | F | C |
| **n** | | 96 | 42 | 138 | 96 | 42 | 138 | 96 | 42 | 138 |
| **Mean** | | 0.31 | 0.35 | 0.32 | 322.9 | 201.6 | 286.0 | 103.7 | 59.5 | 90.3 |
| **SD** | | 0.02 | 0.05 | 0.04 | 54.6 | 46.5 | 76.5 | 19.4 | 8.7 | 26.5 |
| **Minimum** | | 0.37 | 0.56 | 0.56 | 159.7 | 117.3 | 117.3 | 63.4 | 42.0 | 42.0 |
| **Percentiles** | **5** | 0.35 | 0.38 | 0.37 | 243.1 | 142.6 | 159.7 | 72.6 | 47.7 | 51.5 |
| | **10** | 0.34 | 0.37 | 0.36 | 255.5 | 155.0 | 182.4 | 79.4 | 48.2 | 55.6 |
| | **25** | 0.32 | 0.36 | 0.34 | 290.0 | 180.8 | 219.8 | 90.8 | 54.1 | 63.5 |
| | **50** | 0.31 | 0.35 | 0.32 | 315.7 | 198.1 | 294.8 | 102.0 | 59.3 | 91.8 |
| | **75** | 0.29 | 0.33 | 0.30 | 360.0 | 218.3 | 346.3 | 114.9 | 63.0 | 111.0 |
| | **90** | 0.29 | 0.32 | 0.29 | 390.9 | 240.3 | 387.8 | 129.9 | 68.1 | 122.8 |
| | **95** | 0.28 | 0.32 | 0.28 | 398.7 | 247.9 | 397.0 | 138.9 | 79.0 | 134.4 |
| **Maximum** | | 0.26 | 0.30 | 0.26 | 461.1 | 403.1 | 461.1 | 154.3 | 83.9 | 154.3 |

[a] Scores inverted so faster (shorter) times = higher percentile

**Table 3.6.** Correlations among Criterion Trasks & Predictor Tests

| | **Foot March** (min) | **Sandbag Carry** (min) | **Casualty Evacuation** (lb) | **Cas Drag Speed** (m/s) |
|---|---|---|---|---|
| **Step Test** | -0.51** | -0.52** | 0.49** | 0.45** |
| **Beep Test** | -0.53** | -0.56** | 0.48** | 0.39** |
| **Sit-Up** | -0.17* | -0.12 | 0.09 | 0.17* |
| **Push-Up** | -0.47** | -0.52** | 0.63** | 0.50** |
| **Arm Ergometer** | -0.62** | -0.72** | 0.79** | 0.77** |
| **SLJ**[1] | -0.47** | -0.63** | 0.67** | 0.71** |
| **300 m Sprint** | 0.60** | 0.65** | -0.63** | -0.57** |
| **Handgrip** | -0.52** | -0.70** | 0.73** | 0.76** |
| **Med Ball Put** | -0.53** | -0.70** | 0.77** | 0.84** |
| **Illinois Agility** | 0.23** | 0.47** | -0.56** | -0.52** |
| **Upright Pull** | -0.51** | -0.70** | 0.80** | 0.83** |
| **Biceps Curl** | -0.53** | -0.68** | 0.79** | 0.80** |

**p<0.01; *p<0.05
[1]Standing Long Jump

**Table 3.7.** Regression Results of Full Predictive Models: Unstandardized Coefficients

| *Tests Excluded from Model* | **Best Model** | | **Best 4-Predictor Model** *Arm Ergometer* | | **No Calibrated Equipment** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl* | | **Stopwatch and Tape Measure Only** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl, Medicine Ball Put* | |
|---|---|---|---|---|---|---|---|---|
| | **ß** | **Std. Error** | **ß** | **Std. Error** | **ß** | **Std. Error** | **ß** | **Std. Error** |
| ***Constant*** | -8.13** | 2.07 | -7.77** | 2.57 | -3.22 | 2.34 | 0.55 | 3.79 |
| **300 m Sprint** | -5.89** | 1.47 | -5.01** | 1.88 | -8.85** | 1.70 | -9.70** | 2.35 |
| **Med Ball Put** | 0.007** | 0.002 | 0.011** | 0.002 | 0.017** | 0.002 | | |
| **Upright Pull** | 0.011** | 0.003 | 0.017** | 0.003 | | | | |
| **AE**[1] | 0.028** | 0.005 | | | | | | |
| **Beep Test** | | | 0.027** | 0.010 | | | | |
| **1-Min Push-Up** | | | | | 0.038* | 0.016 | 0.84** | 0.020 |
| **SLJ**[2] | | | | | | | 0.039** | 0.009 |
| **1-Min Sit-Up** | | | | | | | -0.038* | 0.018 |
| **R-squared** | **0.82** | | **0.79** | | **0.75** | | **0.63** | |
| **Adj. R-squared** | **0.83** | | **0.79** | | **0.75** | | **0.62** | |
| **Std. Error of Measurement** | **1.47** | | **1.59** | | **1.73** | | **2.12** | |

n=138; * p<0.05, ** p<0.01 for covariates.
p<0.01 for all full models.
Covariates not shown did not significantly contribute to any models.
[1] 2-Min Arm Ergometer
[2] Standing Long Jump

**Table 3.8.** Regression Results of Predictive Models: Predictive Capabilities

| | | All Tests Combined Full Model Adj. $R^2$ | Individual Test r | | | |
|---|---|---|---|---|---|---|
| | | | Foot March | Sandbag Carry | BFV Cas Evac | Casualty Drag |
| **Best 4-Predictor** | 300 m Sprint + Medicine Ball Put + Upright Pull + AE[1] | **0.82** | 0.67 | 0.79 | 0.86 | 0.88 |
| **No Arm Ergometer** | 300 m Sprint + Medicine Ball Put + Upright Pull + Beep Test | **0.79** | 0.67 | 0.79 | 0.84 | 0.88 |
| **No Calibrated Equipment** | 300 m Sprint + Medicine Ball Put + 1-Min Push-Up | **0.75** | 0.65 | 0.76 | 0.82 | 0.84 |
| **Stopwatch & Tape Measure Only** | 300 m Sprint + 1-Min Push-Up + SLJ[2] + 1-Min Sit-Up | **0.62** | 0.63 | 0.71 | 0.78 | 0.73 |

[1] 2-Min Arm Ergometer
[2] Standing Long Jump

**Table 3.9.** Physical Domains of Current and Proposed Military Employment Testing Batteries

| | | Strength | Power | Muscular Endurance | Aerobic Capacity | Agility |
|---|---|---|---|---|---|---|
| *Existing Test Batteries* | **Australia** (3) | Box Lift and Place | | Jerry Can Carry<br><br>Weight Load Carry | Weight Load Carry | Fire and Movement |
| | **Canada** (6, 9) | | Sandbag Drag | Sandbag Lift<br><br>Intermittent Loaded Sandbags | Sandbag Lift<br><br>Intermittent Loaded Sandbags | 20 m Rushes |
| | **United Kingdom** (5, 27, 28) | Static Lift | | Jerry Can Carry<br><br>2-min Push-Up<br><br>2-min Sit-Up | 1.5-mi Run | |
| *Proposed 12B Test Batteries* | **Best** | Upright Pull | Med Ball Put<br><br>300 m Sprint | Arm Ergometer<br><br>300 m Sprint | | |
| | **No Arm Ergometer** | Upright Pull | Med Ball Put<br><br>300 m Sprint | 300 m Sprint | Beep Test | |
| | **No Calibrated Equipment** | | Medicine Ball Put<br><br>300 m Sprint | 1-min Push-Up<br><br>300 m Sprint | | |
| | **Stopwatch & Tape Measure** | | 300 m Sprint<br><br>SLJ[1] | 1-min Push-Up<br><br>1-Min Sit-Up<br><br>300 m Sprint | | |

[1]Standing Long Jump

**Figure 3.1.** Schematic of the Illinois Agility Test

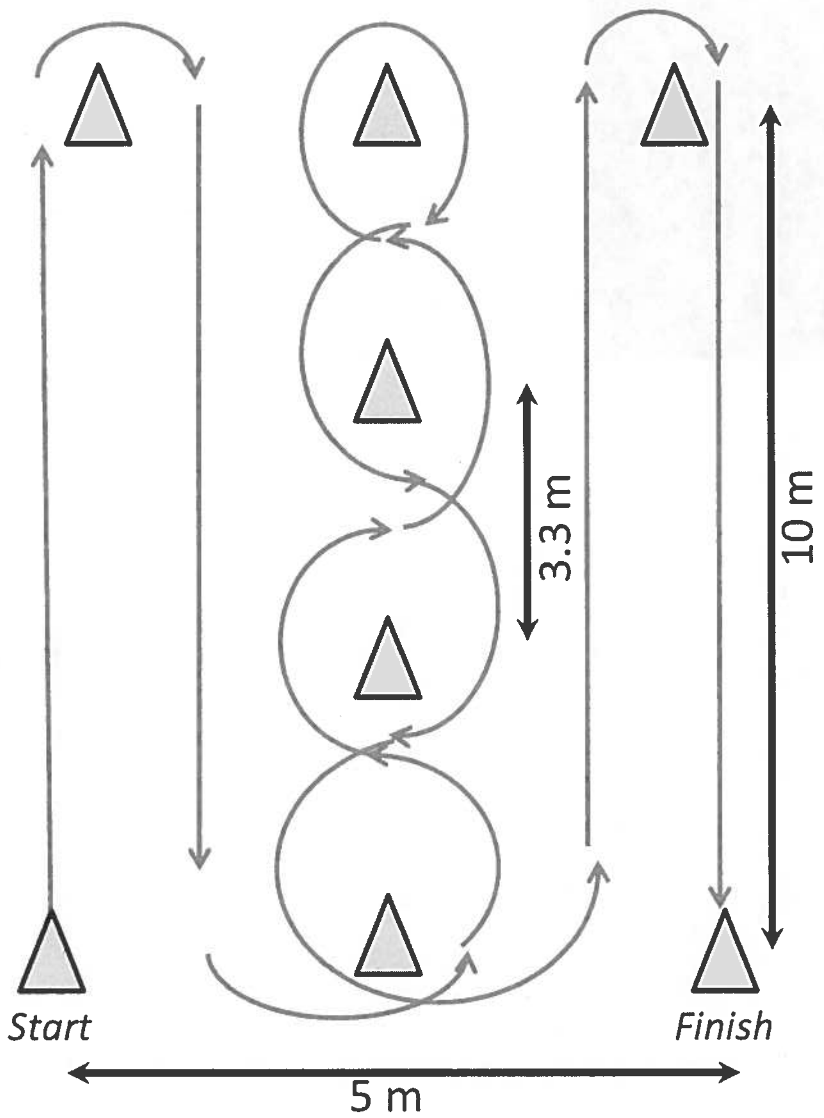


**Figure 3.2.** Image of Arm Ergometer Test

## CONCLUSIONS

This set of three studies used best practices set out by Payne and Harvey to develop a physical testing battery for 12B. Study 1 identified the most physical demanding tasks. Of the 13 physically demanding tasks listed by SMEs, four tasks were identified as capturing the physical demands of the set. The foot march captured load carriage; casualty evacuation captured heavy lifting; sandbag carry captured repeated lifting and carrying, and the casualty drag captured heavy drags. Following approval of the task selection by SMEs, task simulations were developed and reliability of the tasks was determined in Study 2. Finally, four models, using different sets of predictor tests, were developed in Study 3. The four models were (from best to worst predictive ability):

1. Arm ergometer, upright pull, 300 m sprint and medicine ball put
2. Beep test, upright pull, 300 m sprint and medicine ball put
3. Medicine ball put, 300 m sprint and 1-min push-up
4. Standing long jump, 300 m sprint, 1-min push-up and 1-min sit-up

The models presented herein are developed specifically using information from the 12B studies. Additional studies were conducted using Soldiers from the Field Artillery (13B, 13F), Infantry (11B, 11C) and Armor (19D, 19K). When these studies are compiled, one overarching test battery of five to seven tests to cover all seven MOSs will need to be developed in order to complete the tasking from TRADOC. This final model will provide a test battery able to accurately predict candidates for each of the seven MOSs.

## RECOMMENDATIONS

- The Combat Engineer MOS contains a number of physically demanding tasks. Given these high demands, a pre-enlistment test battery would be beneficial in preventing injuries and misclassifications.
- The Army should institute either one of the predictive test batteries presented herein or wait until the completion of this study to institute a test battery common to all Combat Arms MOSs.
- Once a test battery is instituted, it will be necessary to perform short-term follow-up assessments to ensure the success of the models in preventing injuries and reclassifications of new Army recruits. Acceptable passing scores may need to be adjusted in order to optimize the model to prevent these negative outcomes.
- Periodic review of the physically demanding tasks of Combat Engineers should be considered. If a new task is identified with greater or different physiological demands, or one of the currently identified criterion tasks is deemed no longer representative of the physical demands, redevelopment of the models should be considered.

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## APPENDIX A. COPY OF ARMY DIRECTIVE 2015-27 (EXPANDING POSITIONS FOR THE ASSIGNMENT OF ENLISTED FEMALE COMBAT ENGINEER SOLDIERS)

SECRETARY OF THE ARMY
WASHINGTON

16 JUN 2015

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Army Directive 2015-27 (Expanding Positions for the Assignment of Enlisted Female Combat Engineer Soldiers)

1. References:

a. Army Regulation 600-13 (Army Policy for the Assignment of Female Soldiers), 27 March 1992.

b. Department of the Army Pamphlet 611-21 (Military Occupational Classification and Structure), 22 January 2007.

2. The Department of the Army is opening military occupational specialty (MOS) 12B, Enlisted Combat Engineer, and seven associated additional skill identifiers to women: 2C (Javelin Gunnery), 6B (Reconnaissance and Surveillance Leaders Course), B6 (Combat Engineer Heavy Truck), D3 (Bradley Fighting Vehicle Operations and Maintenance), J3 (Bradley Infantry Fighting Vehicle (BIFV) System Master Gunner), K9 (Combat Engineer Mine Detection Dog Handler), and S4 (Sapper Leader). This directive applies to all three Army components.

3. This MOS was the only remaining MOS within the Engineer Career Management Field closed to women. By opening this MOS and the associated skill identifiers, the Army opens approximately 20,563 positions to women. Accordingly, this directive announces a limited modification to Army Regulation 600-13 and Department of the Army Pamphlet 611-21 to permit female Soldiers to attend training and, as a result, be awarded the MOS and respective additional skill identifiers, where appropriate.

4. Division and Corps G-1s, U.S. Army Human Resources Command, and brigade-level commanders and S-1s are responsible for executing the provisions of this directive.

5. The Army National Guard (ARNG) Directorate G-1, State Adjutants General, commanders and S-1s are responsible for executing the provisions of this directive in ARNG units. The ARNG will provide additional implementing guidance to its commanders and S-1s.

6. The 30-day congressional notification process required by Title 10, U.S. Code, section 652 was completed on 21 May 2015. This directive is effective immediately.

SUBJECT: Army Directive 2015-27 (Expanding Positions for the Assignment of Enlisted Female Combat Engineer Soldiers)

7. The Deputy Chief of Staff, G-1 is the proponent for this policy and will incorporate it into the next revision of Army Regulation 600-13 and Department of the Army Pamphlet 611-21. This directive is rescinded upon publication of the revised regulations.

John M. McHugh

John M. McHugh

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SUBJECT: Army Directive 2015-27 (Expanding Positions for the Assignment of Enlisted Female Combat Engineer Soldiers)

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## APPENDIX B. LIST OF PARTICIPANTS ON REVIEW PANEL FOR DEVELOPING TASK STANDARDS FOR 12B COMBAT ENGINEERS

**Branch Review Panel**

MG Todd Semonite, USACE DCG
BG Margaret Burcham, USACE Division Commander
COL Loretta Deaner, Army Reserve Installation Management Division Director
COL David Hill, 36th EN Brigade Commander
COL Nicholas Katers, 555th EN Brigade Commander
CSM David Clark, 18th EN Brigade CSM
CSM Butler Kendrick, 2BCT CSM

**Office, Chief of Engineer (OCOE) Proponency SMEs:**

BG Duke Deluca, EN Regimental Commandant
COL Barry Williams, EN Assistant Regimental Commandant
MAJ Samantha Bebb, EPDO Chief
CW4 Corey Hill, EPDO Deputy Chief
CSM Terrence Murphy, EN Regimental CSM
SGM Bill Lindsey, EPDO SGM
MSG Todd Moyer, EPDO
MSG Wilson Reyes, EPDO
MSG Marcus Tripp, EPDO

## APPENDIX C. 12B UNIFORM LOAD VARIANTS

### Soldier Load

**Uniform 12.4 lbs**

| | |
|---|---|
| Boots | 5.00 |
| ACU | 3.20 |
| Multi tool | 0.50 |
| Rigger Belt | 0.50 |
| Patches | 0.49 |
| Patrol Cap | 0.48 |
| ID Tags | 0.38 |
| Undershirt | 0.35 |
| Gloves | 0.25 |

**12.4 lbs**

| | |
|---|---|
| Eye Pro | 0.25 |
| Notebook | 0.25 |
| Drawers | 0.20 |
| Socks | 0.20 |
| Wrist Watch | 0.19 |
| Ear Plugs | 0.13 |
| Chapstick | 0.01 |
| ID Card | 0.01 |

**Personal Protective Equipment and Weapon (PPE) 63.03 to 77.60 lbs***

| | |
|---|---|
| 100 oz Hydration system ( With Water) | 7.10 |
| Fighting Load Carrier | 1.25 |
| 30 round magazine pouch (3 x 0.25) | 0.75 |
| Hand grenade pouch (2) with (2) M67 Fragmentation Grenades | 1.86 |
| Lensatic Compass w/case | 0.27 |
| Individual First Aid Kit (IFAK) | 1.08 |
| Mag light flashlight w/2 ea AA battery | 0.24 |
| Infrared signal beacon, PHOENIX w/Battery | 0.70 |
| Ballistic Knee/Elbow Pads | 0.79 |
| Visual/Language Translator Card | 0.01 |
| Casualty Feeder Report/ Witness Statement | 0.01 |
| Advanced Combat Helmet (ACH) | 3.25 |
| Helmet Cover w/camouflage cover band | 0.28 |
| Night Vision goggle mounting plate | 0.20 |
| Ballistic Protection Goggles (ESS) | 0.15 |
| M4 Carbine w/fully loaded magazine | 7.50 |

| | |
|---|---|
| M68- CCO w/ battery | 0.71 |
| 3 point sling | 0.30 |
| Back-Up Iron Sight | 0.32 |
| M-4 RAS & Fwd Pistol Grip | 1.55 |
| 5.56mm Magazine with 30 rounds each (6 ea) | 6.42 |
| Sure Fire light w/ battery | 0.50 |
| PAQ-4C w/batteries | 0.90 |
| | **36.14** |
| IOTV w/ neck/groin protector | 11.69-19.63* |
| Enhanced Small Arms Protective Inserts | 7.60-14.20* |
| Enhanced Side Ballistic Insert set with Side Plate Carrier | 7.60 |
| | **63.03 to 77.57 lbs** |

Uniform 12.4 lbs + PPE 63.03 to 77.57 lbs*
= **Fighting Load 75.43 to 89.97 lbs***

V1, 5 Sep 2013

* see slide 4, Weights for IOTV Gen II

### Soldier Load - <24 hour Sustainment Load

**Sustainment Load Carried in Assault Pack**

| | |
|---|---|
| Assault Pack w/ waist pack | 4.2 |
| 2QT Canteen w/Cover and Sling w/water | 4.15 |
| Liner Poncho | 1.14 |
| Poncho | 1.05 |
| Improved Rain suit Top | 1.7 |
| Improved Rain suit Bottom | 1.7 |
| Neck Gaiter | 1 |
| Meal Ready To Eat 1 ea (1.50/0.68 kg) | 1.5 |
| Undershirt moisture wicking x 1 ea | 0.35 |
| Socks x 1 pr | 0.2 |
| Improved Cleaning Kit | 1.6 |
| Flexi Cuffs (4 large per soldier) | 0.04 |
| Chemlight (2per) | 0.04 |
| Water purification tablets | 0.02 |
| Camo Face Paint | 0.02 |
| VS17 Panel (small) | 0.3 |
| | **19.0 lbs** |

| | |
|---|---|
| Uniform | 12.4 |
| PPE | 63.03 to 77.57 * |
| + <24 Hr Sustainment Load | 19.0 |
| Approach March Load | 94.43 to 108.97 lbs* |

V1, 5 Sep 2013

* see slide 4, Weights for IOTV Gen II

# APPENDIX D. TASK DESCRIPTION SLIDES PROVIDED BY TRADOC

## Task 1: Conduct Tactical Movement
## 11B, 11C, 19D, 19K, 13F, 12B

**Task:** Conduct a 24 Kilometer Tactical Movement

**Condition:** Wearing / Carrying 94 – 109 lbs Evenly Distributed Across the Entire Body

**Standard:** Complete in not less than 22 or more than 24 hours; the entire distance should not be completed in one segment.

| Conduct Tactical Movement<br>**Carry minimum of 102 lbs evenly distributed over entire body and remain able to fight at conclusion of march of 24 kilometers per day.** | |
|---|---|
| Weight: 94-109 lbs<br>Horizontal Distance: 24 km<br>Vertical Distance: Terrain Dependant<br>Time: 24 hours | Weight: 94-109 lbs is combined weight of Basic Soldier Uniform (12 lbs), PPE (63.03 to 77.57 lbs), and <24 hour sustainment load (19 lbs)<br>Horizontal Distance: Army Standard for Tactical Movement is 3-4 km per hour. 24 km per day is representative of 2 Combat Patrols (6-8 km out and 6-8 km back twice a day) from Combat Outposts and Joint Security Sites<br>Time: 22 to 24 hours |

- This is not an individual event, however, all platoons and squads do not have to complete the event at the same time.

- Platoon/Squad Leaders may adjust the rate of movement as necessary while still maintaining the ability to complete the task in 22 to 24 hours.

- Soldiers who do not finish with their platoon/squad should be counted as No-GOs.

V1, 5 Sep 2013

## Task 2: Employ Hand Grenades
## 11B, 11C, 19D, 19K, 13B, 13F, 12B

**Task:** Employ Hand Grenades

**Condition:** Wearing / Carrying 63.65 to 78.19** lbs Fighting Load(no weapon) and given two M69 Practice Hand Grenades

**Standard:** Throw at least one Hand Grenade 30 meters

| Employ Hand Grenades<br>**Throw hand grenade to engage enemy forces** | |
|---|---|
| Weight: 1 lb<br>Horizontal Distance: 30 m<br>Vertical Distance: N/A<br>Time: N/A | Weight: M67 Fragmentation Grenade or M69 Practice Hand Grenade<br>Horizontal Distance: Doctrinally, the Army considers 30 m to be hand grenade range, 30 m engages a 35 m target |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor
** 63.65 to 78.19 lbs is fighting load minus 11.78 lbs for M4 & items attached to the M4

## Task 3: Prepare a Fighting Position (Fill and Emplace Sandbags)
## 11B, 11C, 19D, 19K, 13B, 13F, 12B

**Task:** Fill Sandbags

**Condition:** Wearing / Carrying 63.65 to 78.19** lbs Fighting Load(-) (no weapon) and given entrenching tool, 26 empty sandbags, sufficient fill

**Standard:** 26 sandbags filled 55-60% full in 52 minutes

| Fill Sandbags<br>Dig, lift, and shovel 11 lbs scoops of dirt in bent, stooped or kneeling position into sandbags. | |
|---|---|
| Weight: 11 lbs<br>Horizontal Distance: N/A<br>Vertical Distance: 0.75 m<br>Time: 52 minutes | Weight: 11 lbs is combined weight of e-tool and average weight of various soil compositions<br>Vertical Distance: 0.75 meters is height of a sandbag, 3-5 scoops of dirt fill one sandbag<br>One hasty fighting position (without overhead cover) uses 26 sand bags<br>Time: 2 minute average to fill a sandbag |

**Task:** Carry / Emplace Sandbags
**Condition:** Wearing / Carrying 64–80* lb Fighting Load(-) (no weapon) and given 26 sandbags (55-60% full)
**Standard:** Hasty fighting position (without overhead cover) built in 26 minutes 10 meters from the original position of the sandbags

| Carry/Emplace Sandbags<br>Lift 30-40 lb sandbags waist to shoulder high, carry them 10 m and emplace | |
|---|---|
| Weight: 30-40 lbs<br>Horizontal Distance: 10 m<br>Vertical Distance: 1 m to 1.5 m<br>Time: 26 minutes | Weight: Based on soil composition and bags filled 55-60%, a sandbag weighs 30-40 lbs<br>Horizontal Distance: 10 meters is farthest distance carried from fill point without a vehicle<br>Vertical Distance: Waist to shoulder height<br>Time: 1 minute to carry/emplace a sandbag |

*Weight range based on difference for sizes XS-4XL of uniform items & body armor
** 63.65 to 78.19 lbs is fighting load minus 11.78 lbs for M4 & items attached to the M4

V1, 5 Sep 2013

## Task 4a: Drag a Casualty to Immediate Safety (Dismounted)
## 11B, 11C, 19D, 19K, 13B, 13F, 12B

**Task:** Individually Drag a Casualty to Immediate Safety

**Condition:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load and given a casualty (~188 lbs) with an 83 lbs Fighting Load for a total weight of ~271 lbs

**Standard:** Casualty dragged 15 meters.

**Evaluator's Note:** See Next Slide

| Soldier on the Ground<br>Individually lift, drag, and carry a casualty to a safe location; casualty is in harm's way | |
|---|---|
| Weight: ~271 lbs<br>Horizontal Distance: 15 m<br>Vertical Distance: 0.5-2 m<br>Time: As quickly as possible | Weight: ~188 lbs incapacitated Soldier with an 83 lb Fighting Load<br>Horizontal Distance: 15m is approximately half the distance a Soldier could move during a 3-5 second rush<br>Vertical Distance: 0.5 - 2 m is height Soldier would carry or drag casualty. |

V1, 5 Sep 2013

## Task 4b: Remove a Casualty from a Vehicle* (Mounted)
## 11B, 19D, 13F, 12B

**Task:** Remove a Casualty from a Vehicle*; Three Soldier Task

**Condition:** See Next Slide

**Standard:** Casualty removed from Vehicle*

* **11B, 19D, 13F:** BFV, Stryker
* **12B:** BFV or Buffalo (Type of Unit Dependant)

| **Lift from the Inside of a Vehicle**<br>**Three Soldiers perform this task from a BFV, Stryker, or Buffalo** | |
|---|---|
| Weight: ~207 lbs (prorated ~103.5 ls)<br>Horizontal Distance: 1-2 m<br>Vertical Distance: 1.5 m<br>Time: 2 Minutes | Weight: ~188 lbs incapacitated Soldier with 19 lbs of Vehicle Crewman Uniform and equipment<br><br>Horizontal Distance: 1.5 m is the height from the commander's seat to the top of the turret<br>Vertical Distance: To clear vehicle |

Three Soldiers perform this task, two on the vehicle and one inside. The two Soldiers on the vehicle lift the vast majority of the casualty's weight. The Soldier in the vehicle primarily guides the casualty.

V1, 5 Sep 2013

## Task 5: Maintain 25mm Gun on a BFV – Install the Barrel
## 11B, 19D, 13F, 12B

**Task:** Install an M242 25mm Barrel on the M242 Gun on a BFV; Two Soldier Task

**Condition:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load and given a BFV with an M242 Gun and an M242 25mm Barrel

**Standard:** Barrel is carried 25 meters and lifted onto BFV hull

**Armor Standard:** Barrel is carried 3 meters and lifted onto BFV hull

**Lift an M242 25mm Barrel onto the Deck of a BFV**

- Removal of M242, 25mm barrel
- Required during maintenance and during remedial action misfire procedures

| **Lift 107 Pounds 1 Meter and Carry 3 Meters or 25 Meters as Part of a 2 Soldier Team** | |
|---|---|
| Weight: 107 lbs (prorated 53.5 lbs)<br>Horizontal Distance: 3 m or 25 m<br>Vertical Distance: 1 m<br>Time: n/a | Weight: Barrel weighs 107 lbs<br>Horizontal Distance: Barrel to BFV<br>Vertical Distance: BFV hull |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 6: Maintain 25mm Gun on BFV – Remove Feeder Assembly
## 11B, 19D, 13F, 12B

**Task:** Remove the M242 Feeder Assembly from the M242 Gun on a BFV

**Condition:** Wearing / Carrying 30-44* lbs (IOTVC with ESAPI and ESBI, CVC/ACH Helmet) and given a BFV with an M242 Gun and an M242 Feeder Assembly

**Standard:** Feeder assembly properly removed

**Remove the M242 Feeder Assembly**

- Required during maintenance and during remedial action misfire procedure

| Lift 59 Pounds 6 Inches and Carry 1 Meter While Seated | |
|---|---|
| Weight: 59 lbs<br>Horizontal Distance: 1 m<br>Vertical distance: 6 in<br>Time: N/A | Weight: M242 Feeder Assembly weighs 59 lbs |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 7: Load 25mm HEI-T Ammunition Can on BFV
## 11B, 19D, 13F, 12B

**Task:** Load 30 25mm High-Explosive Incendiary Tracer (H-EIT) Ammo Cans onto a BFV

**Condition:** Wearing / Carrying 63.65 to 78.19** lbs Fighting Load(-) (no weapon) and given a BFV and 30 Ammo Cans with 45 Rounds of H-EIT per can

**Standard:** 30 Ammunition Cans carried 15 meters and loaded onto BFV 75.43 to 89.97 lbs*

| Lift 45 Pounds Waist High and Carry 5 or 15 Meters | |
|---|---|
| Weight: 45 lbs<br>Horizontal Distance: 15 m<br>Vertical distance: 1 m<br>Time: N/A | Weight: One 25mm ammunition can weighs 45 lbs (contains 45 rounds)<br>Basic Load (25mm) for a BFV is 900 rounds (30 ammunition cans)<br>Horizontal Distance: 15 m is an estimated safe distance between the back of the BFV and the ammunition supply point or ammunition carrier<br>Vertical Distance: 1 m is waist high |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor
** 63.65 to 78.19 lbs is fighting load minus 11.78 lbs for M4 & items attached to the M4

## Task 27: Quickly Create a Footpath Through Various Obstacles 12B

**Task:** Move to Obstacle with Antipersonnel Obstacle Breaching System (APOBS); 2 Soldier Task

**Conditions:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load plus APOBS (60 lbs per Soldier), Total Weight: 135.43-149.97 lbs*

**Standard:** Move APOBS 2 kilometers in 60 minutes

### Perform Foot March

**Walk, Run, and Climb Over Varying Terrain for a Distance of 2 Kilometers with 120 Pound APOBS; 2 Soldier Task**

| | |
|---|---|
| Weight: 120 lbs (prorated 60 lbs)<br>Horizontal Distance: 2 km<br>Vertical Distance: Terrain Dependant<br>Time: 60 minutes | Weight: APOBS weighs 120 lbs<br>Horizontal Distance: Vehicle to breach site is up to 2 km |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 28: Prepare Obstacle with the H6 40 Pound Cratering Charge 12B

**Task:** Prepare Obstacle with the H6 40 Pound Cratering Charge

**Condition:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load and given 5 H6 40 Pound Cratering Charges 100 Meters from Obstacle Site

**Standard:** Five H6 Catering Charges are placed in a row 100 meters from stockpile

### Carry / Emplace the H6 40 lb Cratering Charge

**Three Cratering Charges are Placed in a Row**

| | |
|---|---|
| Weight: 40 lbs<br>Horizontal Distance: 100 m<br>Vertical Distance: 1 m to 1.5 m<br>Time: n/a | Weight: H6 weighs 40 lbs<br>Horizontal Distance: Stockpile to emplacement area<br>Vertical Distance: Waist to chest height |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 29: Operate a Modular-Pack Mine System (MOPMS)
## 12B

**Task:** Carry / Emplace the MOPMS; 2 Soldier Task

**Conditions:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load and given a vehicle with a MOPMS

**Standard:** MOPMS carried and emplaced 100 meters from the vehicle

| Carry / Emplace the MOPMS<br>As a 2 Soldier Team | |
|---|---|
| Weight: 160 lbs (prorated 80 lbs)<br>Horizontal Distance: 100 m<br>Vertical Distance: 2 m<br>Time: As quickly as possible | Weight: MOPMS weighs 160 lbs<br>Horizontal Distance: Vehicle to emplacement site<br>Vertical Distance: Vehicle |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 30: Assist in the Construction of a Bailey Bridge
## 12B

**Task:** Assist in the Construction of a Bailey Bridge; Lift, Carry, and Emplace the Rocking Roller Template, Bridge Bearing and Rocking Roller; Heaviest Lift is the 206 Pound Rocking Roller (2 Soldier Lift, Prorated 103 lbs); 2 Soldier Task

**Condition:** Wearing / Carrying 75.43 to 89.97 lbs* Fighting Load with the Base Plate in place and given a Rocking Roller Template, Bridge Bearing, and Rocking Roller

**Standard:** Soldiers lift, carry, and place Rocking Roller Template, Bridge Bearing, then Rocking Roller

| Lift and Carry Rocking Roller and Additional Bridge Components<br>3 components with weights range from 68 to 206 pounds, carried by 2 Soldier team | |
|---|---|
| Weight: 206 lbs (prorated 103 lbs)<br>Horizontal Distance: 50 m<br>Vertical Distance: 1 m<br>Time: n/a | Weight: Rocking roller (heaviest prorated weight of all components) weighs 206 lbs<br>Horizontal Distance: up to 50 meters<br>Vertical Distance: Waist |

V1, 5 Sep 2013

*Weight range based on difference for sizes XS-4XL of uniform items & body armor

## Task 31: Install a Volcano Mine System
12B

**Task:** Install a Volcano; 2 Soldier Task

**Conditions:** Wearing / Carrying 16* lb Uniform with ACH & cover (no body armor, no weapon, no camelback, no ammunition, no fighting load carrier, no individual protective equipment, no first aid kid), and given a Volcano (on the ground) and a cargo vehicle

**Standard:** Volcano is properly assembled in the bed of the vehicle

### Set up Volcano

**Lift Beam Frame, two Tripod Assemblies and two Launcher Racks (2 Soldier lift ranging from 151-370 pounds) from ground, carry to the bed of the cargo vehicle and lift 2 meters in the air to give to the receiving team on the cargo vehicle.**

| Task | Max Payload Ind / Team (lb) | Max Distance (m) | Max Height (m) | Reps |
|---|---|---|---|---|
| Lift, receive, install Beams | 185 / 370 | 5 | 2 | 1 |
| Lift, receive, install Tripod Assembly | 75 5 / 151 | 5 | 2 | 2 |
| Lift, receive, install Launcher racks | 113 / 226 | 5 | 2 | 4 |

V1, 5 Sep 2013

## APPENDIX E. PRE-TESTING TRAINING SCHEDULE FOR POTENTIAL STUDY 1 PARTICIPANTS

Occupational Physical Standard Review
Training Schedule
WK 48/49

| Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|
| 26-Aug-13 | 27-Aug-13 | 28-Aug-13 | 29-Aug-13 | 30-Aug-13 |
| 2-Sep-13 | 3-Sep-13 | 4-Sep-13 | 5-Sep-13 | 6-Sep-13 |
| Physical Training WK 48/49 | | | | |
| Two Mile Run/Upper Body | Ruck March | Three Miles LSU/Upper Body | Ruck March | Two Mile Run/Upper Body |
| Endurance, Cratering Charge, Volcano,MOPMS, Rocking Roller, Casualty Drag/Remove from VEH, Install 25MM Barrel, Remove Feeder, 25MM AMMO Carrie, Employ Hand Grenades | Tactical Movement, APOBS, MOPMS, | Endurance, Cratering Charge, Volcano,MOPMS, Rocking Roller, Casualty Drag/Remove from VEH, Install 25MM Barrel, Remove Feeder, 25MM AMMO Carrie, Employ Hand Grenades | Tactical Movement, APOBS, MOPMS | Endurance, Cratering Charge, Volcano,MOPMS, Rocking Roller, Casualty Drag/Remove from VEH, Install 25MM Barrel, Remove Feeder, 25MM AMMO Carrie, Employ Hand Grenades |
| | | | | |
| Task Training Schedule WK 48 | | | | |
| Task 2 SGT Dunaway | Task 27 SGT Smith | Task 31 SSG Rubach | TA-50 Layout | Labor Day Weekend |
| Task 3 SGT Smith | Task 28 SGT Molina | Task 4a/4b SGT Molina | Soldiers Weight In | |
| Task 4a/4b SGT Molina | Task 29 SGT Reynolds | Task 5 SGT Reynolds | | |
| Task 5 SGT Reynolds | Task 30 SGT Dunaway | Task 6 SGT Smith | | |
| Task 6 SGT Smith | Task 31 SSG Rubach | Task 2 SGT Dunaway | | |
| Task 7 SGT Reynolds | | Task 3 SGT Smith | | |
| | | | | |
| Task Training Schedule WK 49 | | | | |
| Labor Day Weekend | Task 2 SGT Dunaway | Task 27 SGT Smith | Soldiers Weigh In | Test All Tasks |
| | Task 3 SGT Smith | Task 28 SGT Molina | PCC/PCI | |
| | Task 4a/4b SGT Molina | Task 29 SGT Reynolds | | |
| | Task 5 SGT Welsh | Task 30 SGT Dunaway | | |
| | Task 6 SGT Smith | Task 31 SSG Rubach | | |
| | Task 7 SGT Reynolds | | | |
| | | | | |
| | | | | |

# APPENDIX F. MINUTES OF THE 12B SUBJECT MATTER EXPERT BRIEFING FOR APPROVAL OF CRITERION TASKS

**12B SME VTC**
4/22/2014

**Soldiers present**
*Fort Carson:*
SFC Kristian Yochum; SFC Christopher Miller

*Fort Lewis McChord:*
SFC Adam Tiffany; SFC Aaron Vitone

*Fort Leonard Wood:*
SFC Jeffrey Munson, SFC Anthony Powers, SFC Jason Arends, SFC Freezal Fuller, SFC Richard Laird

*USARIEM Personnel:*
Ms. Marilyn Sharp, Dr. Edward Zambraski, MAJ Bradley Warr, Dr. Jan Redmond, CPT Laurel Smith, Dr. Stephen Foulis, Dr. Joseph Seay, Ms. Katie Larcom

Mrs Sharp described the study, what has been accomplished thus far, what we plan to do in the future, the task categories and how we decided up on the simulation tasks for each category.

**Heavy lifting tasks- casualty evacuation from a vehicle**

When asked what task in the heavy lifting task category is the most important/physically demanding, all the SMEs from each location agreed it was the casualty evacuation from a vehicle.

Mrs Sharp described how we plan to simulate the casualty evacuation task. When asked if this is a reasonable approach to simulating this task, all the SMEs from each location agreed it is.

Ft Lewis: "You can gradually increase the weight or have the Soldiers choose the bag weight they think they can lift. My only concern is the more times they lift the bag the more fatigued they will become."

*All SMEs agree this is a reasonable approach to simulating this task.*

**Repetitive Lift and Carry- Carry and Emplace Sandbags**

When asked what task in the repetitive lift and carry category they thought was the most important/physically demanding, SMEs from all locations agreed it would either be transferring ammunition or carrying sandbags.

> "Soldiers will be exposed to both sandbags and ammo cans, but everyone across the board may be exposed to the same sandbags. They won't necessarily be exposed to the same ammo cans."

Marilyn described how we plan to simulate the sandbag carry. When asked if this is a reasonable approach to simulating the task, all the SMEs from each location agreed it is.
When asked if they thought it is reasonable to have Soldiers do 16 sandbags during the simulation as opposed to the standard 26, all SMEs from each location agreed it is.

> "Why wouldn't we just have them do the full 26 sandbags?"
>
> > Mrs Sharp and MAJ Warr: From our experience having the Soldiers carry and emplace 26 sandbags did not provide any more information than having them carry 16 as their $VO_2$ hit a plateau after 16 sandbags."

*All SMEs from each location agreed this is a reasonable approach to simulating this task.*

**Dragging- Drag a Casualty to Safety**
When asked if dragging a casualty to safety is an important/physically demanding task, all the SMEs from each location agreed it is.
Mrs Sharp described how we plan to simulate the casualty drag. When asked if this is a reasonable approach to simulating the task, all the SMEs from each location agreed it is.
When asked if they had any issues or problems with this task, all the SMEs from each location said no.

**Load Carriage- Foot March**
When asked what the most important/physically demanding task in the load carriage category is, all the SMEs from each location identified the Tactical March.
Mrs Sharp described how we plan to simulate the Tactical March. When asked if this is a reasonable approach to simulating this task, all the SMEs from each location agreed it is.
When asked if 4 miles is a reasonable distance to test, all the SMEs from each location agreed it is.

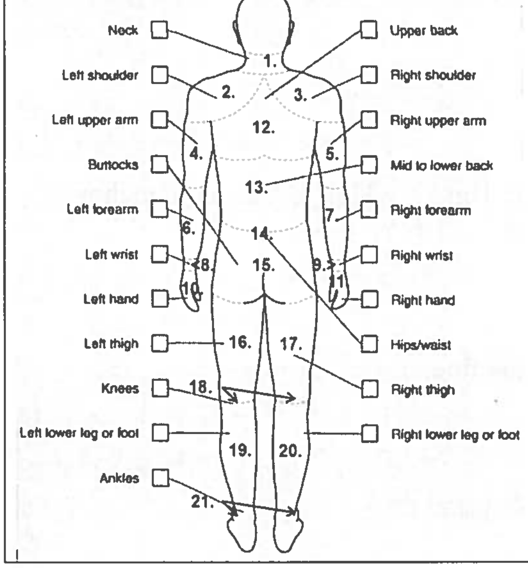
> "This task makes sense in terms of time and distance."
>
> "I hold my Soldiers, both male and female, to a 3 hour 12-mile standard wearing full battle rattle and they all make it. I make sure they are properly trained for it though."

At the end of the VTC, the Soldiers were asked whether or not they were comfortable with the tasks we chose to simulate. All agreed to the tasks.

## APPENDIX G. SCALES USED DURING TESTING

Pain & Discomfort Scale ADAPTED FROM DIMOV ET AL *AIHAJ* 2000

The purpose of this scale is to identify the amount of discomfort you are experiencing in each region of your body. Discomfort includes any feelings of tiredness or pain.




**Discomfort Scale**

0: No Discomfort
1: Uncomfortable
2: Very Uncomfortable
3: Extremely Uncomfortable

Identify all regions in which you are currently feeling any discomfort and then rate that discomfort from 0-3.

If you are not experiencing any discomfort, you may skip that region.

# Borg CR10 Scale

**Brief Instruction:** "During the job task, pay close attention to the exertion required for the physical work, which, should reflect your total amount of effort and fatigue. Don't be concerned with any one factor (e.g., duration, leg pain, shortness of breath); concentrate on your total body feeling of exertion. It's your own feeling that is important, not how it compares to other people or what other people think. Be as accurate as you can."

**Continue for Initial Instruction:**

"The scale goes from, "0, nothing at all," to "10, Extremely Hard," which is the main anchor, and is the hardest effort most people have ever experienced.

0 "Nothing at all" You are lifting no weight.

3 "Moderate" Task is not especially hard or difficult. It feels fine.

7 "Very Hard" You have to push yourself very much.

10 "Extremely Hard" You are doing as much as you possibly can do.

(Adapted from: Adapted from 1998 Borg HK, ACSM's Guidelines for Exercise Testing and Prescription 7th Edition, and Borg 1990 SJWEH - Psychophysical scaling with applications in physical work and the perception of Exertion)

| | |
|---|---|
| 0 | Nothing at all |
| 0.5 | Extremely Light |
| 1 | Very Light |
| 2 | Light |
| 3 | Moderate |
| 4 | |
| 5 | Hard |
| 6 | |
| 7 | Very Hard |
| 8 | |
| 9 | |
| **10** | **Extremely Hard** |

# Borg 6-20 Scale

**Brief Instruction:** "During the job task, we want you to pay close attention to how hard you feel the physical work rate is. This feeling should reflect your total amount of exertion and fatigue, combining all sensations and feelings of physical stress, effort, and fatigue. Don't concern yourself with any one factor such as leg pain, shortness of breath, or exercise intensity. It's your own feeling of effort and exertion that is important, not how it compares to other people or what other people think. Be as accurate as you can."

**Continue for Initial Instruction:**
"Look at this rating scale; we want you to use this scale from 6 to 20 where 6 means "no exertion at all," and 20 means "maximal exertion."

9 corresponds to "very light" exercise. For most healthy people it represents walking slowly at their own pace for several minutes.

13 corresponds to "somewhat hard" exertion, but it still feels OK to continue.

17 corresponds to "very hard" or difficult exercise. A healthy person can still go on but they really have to push themselves. It feels very strenuous and the person is very tired.

19 corresponds to very strenuous exercise. To most people it is the most strenuous exercise they have ever experienced.

Try to appraise your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task."

(Adapted from: Adapted from 1998 Borg HK, ACSM's Guidelines for Exercise Testing and Prescription 7th Edition, and Borg 1990 SJWEH - Psychophysical scaling with applications in physical work and the perception of Exertion)

| | |
|---|---|
| 6 | No exertion at all |
| 7 | |
| | Extremely light |
| 8 | |
| 9 | Very light |
| 10 | |
| 11 | Light |
| 12 | |
| 13 | Somewhat hard |
| 14 | |
| 15 | Hard |
| 16 | |
| 17 | Very hard |
| 18 | |
| 19 | Extremely hard |
| 20 | Maximal exertion |

## APPENDIX H. TASK INSTRUCTIONS FROM STUDY 1

### *1. Conduct a Tactical March (24-hour Sustainment Load and Weapon)*

This task will allow us to measure the energy expenditure of soldiers during a tactical road march. In this task, you will be asked to walk on a treadmill for 20 minutes at a speed of 2 mph while carrying about 103 lbs of equipment. You need to check that your heart rate monitor is working. You will be outfitted with a face mask attached by a hose to a metabolic cart. The cart will allow us to measure your energy consumption during the task. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 6-20, with 6 being very easy and 20 being maximum effort. Your average oxygen consumption, heart rate, and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task. If you feel dizzy or are worried you might fall, hold onto the side of the treadmill and step off the belt. You can also press the stop button if needed.

### 3. *Prepare a Fighting Position (Fill and Emplace Sandbags)*

In this task, you will work with a partner to fill and emplace 26 sandbags. You will be outfitted with a face mask attached to a small device worn on your back called an oxycon. The oxycon will allow us to measure your oxygen consumption. Once instrumented, you will fill each of these buckets 13 times up to the line indicated on the inside using an entrenchment tool for a total of 26 buckets. A test administrator will count the buckets and empty them after you fill them. After filling all 26 sandbags, you will be asked to rate how hard you think you worked during the task on a scale from 6-20, with 6 being very easy and 20 being maximum effort by pointing to a number on a scale. You will then lift and carry 26 sandbags a distance of 10 meters where you will build a fighting position. A template is provided for the fighting position. The fighting position is three sided. Each side is three sandbags in length and three sandbags tall. Upon completion of the fighting position, you will be asked to rate how hard you worked during the task using the same scale as before. It is important that you do your best throughout the task, but this is not a race. Perform the task rapidly, as you would during a combat deployment and place, do not throw, the sandbags.

### 4a. *Drag a Casualty to Immediate Safety (Dismounted)*

In this task, you will be asked to drag a casualty to safety. You need to check that your heart rate monitor is working. Upon auditory signal, you will drag a casualty weighing approximately 270 lbs a distance of 15 meters as quickly as possible (from this line to the line over there). The test isn't over until the dummy's feet cross the line. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on this scale (show copy of the scale) from 0-10, with 0 being no exertion at all and 10 being maximum effort. We will also ask you to read and call out your heart rate. The grader will also be walking next to you with an alternate heart rate watch. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment. Before we get started you should jog in place or do some jumping jacks to warm up. You will be given an opportunity to drag the dummy a few feet prior to the real test, so that you get a feel for the weight.

**4b. *Remove a Casualty from a Wheeled Vehicle (Mounted)***

The purpose of this task is to measure your ability to remove a casualty from the BFV and to determine how difficult you think it is to do this. Upon auditory signal, you will pull a casualty weighing approximately 207 lbs from the commander's seat of a BFV as quickly as possible. Two Soldiers will be on top of the BFV, while one soldier is inside. The two soldiers on top will do most of the work of lifting the wounded soldier out of the turret. The soldiers on top will kneel down and reach into the turret, grasping the straps of the heavy bag placed on the driver's seat. The person inside will help guide the wounded soldier out of the turret, but will only minimally assist with the lift. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 0-10, with 0 being no exertion at all and 10 being maximum effort. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment. Prior to beginning you will jog in place and stretch to warm up. Protecting your lower back is very important during this task. If you feel any pain or discomfort you should stop.

**5. *Lift, Carry, and Install the Barrel of a 25mm Gun on the Bradley Fighting Vehicle (BFV)***

In this task, you and one other Soldier will carry the 107-lb barrel of a 25mm gun a distance of 25 meters from a starting point to a BFV and lift it onto the hull of the BFV. One soldier will support the barrel while the second soldier climbs up onto the hull. The solider on the hull will stabilize the barrel while the second soldier climbs up. The barrel will be lifted and placed into the mount opening. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 0-10, with 0 being no exertion at all and 10 being maximum effort (show appropriate RPE scale). The time it takes you to carry and install the barrel and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment and be careful with the equipment.

**6. *Remove the Feeder Assembly of a 25mm Gun on the Bradley Fighting Vehicle (BFV)***

In this task, you will remove the 59-lb M242 feeder assembly from the gun on the BFV and place it on the floor in the rear of the vehicle as quickly as possible. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 0-10, with 0 being no exertion at all and 10 being maximum effort (familiarize soldier with the scale). The time it takes you to remove the feeder assembly and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment and be careful with the equipment.

### 7. *Load 25mm HEI-T Ammunition Cans onto the Bradley Fighting Vehicle*

The purpose of this task is to measure your energy expenditure during the loading of 25mm ammo cans onto a BFV. In this task, you will be asked to load 30 ammunition cans onto a shelf the height of the tailgate of the Bradley Fighting Vehicle. You will be outfitted with a face mask attached to a small device worn on your back called an Oxycon. The Oxycon will allow us to measure your oxygen consumption. Upon auditory signal, you will lift a 45-lb can of 25mm ammunition, carry it 15 meters and place it onto the platform. You will repeat this at your own pace until 30 cans have been moved. You may carry two cans at a time if you wish. Treat these cans as if they were live ammunition. The cans should be placed onto the platform, not thrown. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 6-20, with 6 being very easy and 20 being maximum effort. The time it takes you to complete the task as well as your maximum oxygen consumption, maximum heart rate, and your rating of perceived exertion will be recorded. It is important that you do your best to work quickly throughout the task, but this is not a race. Perform the task as you would during a combat deployment. Prior to starting you should jog or do jumping jacks to warm up. In addition, make sure you stretch and move your arms, back and legs through a full range of motion.

### 27. *Carry and Emplace the Anti-Personnel Obstacle Breaching System (APOBS)*

In this task, you will be asked to carry the Anti-Personnel Obstacle Breaching System (APOBS) on your back. You need to check that your heart rate monitor is working. You will also be outfitted with a face mask attached by a hose to an oxygen uptake measurement system. This device will allow us to measure your oxygen consumption during this task. Upon auditory signal, you will walk on a treadmill, carrying the 60-lb APOBS on your back, at a self-selected comfortable pace for 2 km. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 6-20, with 6 being very easy and 20 being maximum effort. The total time it takes you to complete the task as well as your maximum oxygen consumption, maximum heart rate, and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment.

### 28. *Carry and Emplace the H6 Cratering Charge*

In this task, you will be asked to carry and emplace 3-H6 Cratering Charges. You need to check that your heart rate monitor is working. You will also be outfitted with a face mask attached by a hose to an Oxycon field measuring device. This device will allow us to measure your oxygen consumption during this task. Upon auditory signal, you will lift a 40 -lb H6 Cratering Charge and carry it to the cone and back for a total distance of 100 m. You will place the charge back on the ground and walk around the cone without a load to simulate going back for the second charge. You will perform three loaded carries and two walks empty handed. Upon completion of the task, you will be asked to rate how hard you think you worked during the task on a scale from 6-20, with 6 being very easy and 20 being maximum effort. The total time it takes you to complete the task as well as your average oxygen consumption, heart rate, and rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment and place the cratering charge carefully on the ground.

### 29. *Carry and Emplace the Modular-Pack Mine System (MOPMS)*

The purpose of this task is to determine the effort required to lower and carry a Modular-Pack Mine System (MOPMS). In a two person team, carry the MOPMS 100 meters. You will lower the MOPMS from the truck. Upon auditory signal you and your partner will pull the MOPMS off the bed of a 5-1/2 ton truck, pull the carry handles out, then lift and carry the 160-lb MOPMS around the cone and back for a total of 100 meters. Upon completion of the task, you will call out your heart rate to the experimenter and then rate how hard you think you worked during the task. The scale goes from 6-20, with 6 being very easy and 20 being maximum effort. The total time it takes you to complete the task as well as your maximum heart rate and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. If you need to rest you can place the MOPMS on the ground. Perform the task as quickly as you would during a combat deployment.

### 30. *Lift and Carry the Rocking Roller during Construction of a Bailey Bridge*

The purpose of this task is to determine the difficulty of carrying a rocking roller. In this task, you and a partner will be asked to lift and carry the three pieces of a Bailey Bridge rocking roller. Upon auditory signal, you and one other Soldier will lift the rocking roller template and bridge bearing, carry them 50 meters and put them together in the proper sequence. You will walk back 50 meter and work together to carry the rocking roller 50 meters. You can rest by placing the rocking roller on the ground. You must communicate with your partner to ensure you lift and lower at the same time. Upon completion of the task, you will call out your heart rate to the experimenter and then rate how hard you think you worked during the task. The scale (shown here) goes from 6-20, with 6 being very easy and 20 being maximum effort. The total time it takes you to complete the task as well as your maximum heart rate and your rating of perceived exertion will be recorded. It is important that you do your best throughout the task, but this is not a race. Perform the task as quickly as you would during a combat deployment.

### 31. *Load and Install a Volcano Mine System*

In this task, you will be asked to install a Volcano Mine System as part of a four soldier team. You need to check that your heart rate monitor is working. Two of you will also be outfitted with a face mask attached by a hose to an Oxycon. This device will allow us to measure your oxygen consumption during this task. Upon auditory signal, you will lift into and install in the assigned cargo vehicle a Volcano Mine System (beam frame, two tripod assemblies, and two launcher racks). Upon completion of the task, you will call out your heart rate to the experimenter and then rate how hard you think you worked during the task. The scale goes from 6-20, with 6 being very easy and 20 being maximum effort. The total time it takes you to complete the task as well as your maximum heart rate and your rating of perceived exertion will be recorded. After the first installation of the Volcano, the system will be disassembled. Soldiers who worked on the ground will move into the truck and Soldiers who worked in the truck will move to the ground during a second installation. It is important that you do your best throughout the task, but this is not a race. Perform the task as you would during a combat deployment.

## APPENDIX I. QUESTIONNAIRES, SURVEYS, AND DATA SHEETS FROM STUDY 1

**Physical Performance Standards Study**

**Ft Hood, TX Sept. 2013**

**Demographics Sheet**

**Subject ID**__________

**MOS** ____________

**Age** _____________

**Sex** ______________

**Height (in)** ____________

**Weight (lbs)** ___________

**Total Time in Military Service (years)** _____________

**Total Time in Current MOS (years)** _____________

**Total Time Deployed in MOS (months)** ____________

**Last Army Physical Fitness Test Score (total)** _____________

**Push-ups (reps)** _____________

**Sit-ups (reps)** ______________

**2-Mile Run Time (min:sec)** _____________

MOS – 12B

**Demographic Data: Please complete the following items.**

Subject ID______________ Birthdate__________ Rank___________ Race___________

Total time of military service (years) ______________

Total time in current MOS (years) ________________

Total time deployed in current MOS (months) ___________

Deployment locations:______________ _____________ _______________

**Directions: Please indicate whether you have performed these tasks in training or while deployed and the number of times you have performed them in each setting.**

| | | *Performed During* | | | |
|---|---|---|---|---|---|
| *Master Task Number/Master Task* | | *Training (Y/N)* | *# of times* | *Deployed (Y/N)* | *# of times* |
| *1* | *Conduct a tactical movement* | | | | |
| *2* | *Employ hand grenades* | | | | |
| *3* | *Prepare a fighting position* | | | | |
| *4a* | *Drag casualty to safety (dismounted)* | | | | |
| *4b* | *Remove casualty from a vehicle (mounted)* | | | | |
| *5* | *Lift, carry, and install the barrel of a 25mm gun* | | | | |
| *6* | *Remove the feeder assembly of a 25mm gun* | | | | |
| *7* | *Load 25mm H-EIT tracer ammunition cans* | | | | |
| *27* | *Carry and emplace the APOBS* | | | | |
| *28* | *Carry and emplace the H6 cratering charge* | | | | |
| *29* | *Carry the Modular-Pack Mine System* | | | | |
| *30* | *Lift and carry rocking roller for Bailey Bridge* | | | | |
| *31* | *Load and install a Volcano* | | | | |

USARIEM

USARIEM MOS Physical Performance Standards Study
Ft Hood, TX
Day 1

Subject ID____________ Uniform= 12.4lbs

Date: ________________ Fighting Load=63.03-77.57lbs

Unloaded Weight (lbs)_______ < 24hr Sustainment Load= 19.0lbs

| | *Task* | *Loaded Weight (lbs)* | *Time (Min:Sec)* | *RPE* | *Pre HR* | *Post HR* | $\dot{V}O_2$ | *Go/No Go** | *Time of Day* | *Investigator Initials* |
|---|---|---|---|---|---|---|---|---|---|---|
| *4b* | Remove a Casualty from Vehicle (Mounted) (Uniform +Fighting Load without weapon) | | | | | | | | | |
| *5* | Lift, Carry, and Install the Barrel of a 25mm gun (Uniform + Fighting Load) | | | | | | | | | |
| *6* | Remove the Feeder Assembly of a 25mm gun (Uniform +30-44lbs) | | | | | | | | | |
| *31* | Load and Install a Volcano (Ground Position) (16lb uniform with ACH and cover) | | | | | | | | | |
| *31* | Load and Install a Volcano (Truck Position) (16lb uniform with ACH and cover) | | | | | | | | | |

***If Soldier is unable to complete the task, please indicate why in the comments section.**

**<u>Comments:</u>**

USARIEM

USARIEM MOS Physical Performance Standards Study
Ft Hood, TX
Day 2

Subject ID___________ Uniform= 12.4lbs

Date: ________________ Fighting Load=63.03-77.57lbs

Unloaded Weight (lbs) _______ < 24hr Sustainment Load= 19.0lbs

| | *Task* | *Loaded Weight (lbs)* | *Time (Min:Sec) Or Pace (mph)* | *RPE* | *Pre HR* | *Post HR* | $\dot{V}O_2$ | *Go/No Go** | *Time of Day* | *Investigator Initials* |
|---|---|---|---|---|---|---|---|---|---|---|
| *27* | Carry and Emplace the APOBS (Uniform + Fighting Load +APOBS) | | | | | | | | | |
| *28* | Carry and Emplace the H6 40 Cratering Charge (Uniform + Fighting Load) | | | | | | | | | |

***If Soldier is unable to complete the task, please indicate why in the comments section.**

**<u>Comments:</u>**

USARIEM MOS Physical Performance Standards Study
Ft Hood, TX
Day 3

Subject ID___________

Date: ________________

Unloaded Weight (lbs) _______

Uniform= 12.4lbs

Fighting Load=63.03-77.57lbs

< 24hr Sustainment Load= 19.0lbs

| | *Task* | *Loaded Weight (lbs)* | *Time (Min:Sec)* | *RPE* | *Pre HR* | *Post HR* | *$VO_2$* | *Go/No Go** | *Time of Day* | *Investigator Initials* |
|---|---|---|---|---|---|---|---|---|---|---|
| *3* | Prepare a Fighting Position (Uniform + Fighting Load minus weapon) | | | | | | | | | |
| *4a* | Drag a Casualty to Immediate Safety (Dismounted) (Uniform + Fighting Load) | | | | | | | | | |
| *29* | Carry and Emplace the Modular-Pack Mine System (Uniform + Fighting Load) | | | | | | | | | |
| *30* | Lift and Carry Rocking Roller for Bailey Bridge (Uniform + Fighting Load) | | | | | | | | | |

***If Soldier is unable to complete the task, please indicate why in the comments section.**

**Comments:**

USARIEM MOS Physical Performance Standards Study
Ft Hood, TX
Day 4

Subject ID___________

Date: ________________

Unloaded Weight (lbs) _______

Uniform= 12.4lbs

Fighting Load=63.03-77.57lbs

< 24hr Sustainment Load= 19.0lbs

| | *Task* | *Loaded Weight (lbs)* | *Time (Min:Sec) Or Pace (mph)* | *RPE* | *Pre HR* | *Post HR* | *$VO_2$* | *Go/No Go** | *Time of Day* | *Investigator Initials* |
|---|---|---|---|---|---|---|---|---|---|---|
| *1* | Conduct a Tactical Movement (Uniform + Fighting Load + Sustainment Load) | | | | | | | | | |
| *7* | Load 25mm H-EIT Tracer Ammunition Cans (Uniform + Fighting Load minus weapon) | | | | | | | | | |

***If Soldier is unable to complete the task, please indicate why in the comments section.**

**Comments:**

## APPENDIX J. TASK INSTRUCTIONS FROM STUDY 2

### 4-Mile Roadmarch Simulation

The purpose of this task is to assess the reliability of completing a 4-mile road march. You will walk as quickly as you can for 4 miles while carrying total load of 103 lbs. While this task should be completed quickly, do not run. Choose a pace that you can maintain and that would allow you to maintain situational awareness to complete a mission. You may take any rest time that you need, but try to finish as quickly as you can.

At the start, you will be asked your HR and current level of discomfort (show discomfort scale and read instructions). You will then place the SPORTident stick in the clear station followed by the start station. When it beeps, your time will begin. At the midpoint, there will be a tester who will ask your HR and RPE (using the 6-20 scale, read instructions if necessary). Respond as quickly as possible, then check out using the other control station and continue on the course. There will be a cone and a stake at the end of each ½ mile. Please walk between the two. Your SPORTident stick will beep as you pass between the marker and the cone. Do not rest within 50 feet of these markers, because the system will record multiple times.

At the end of the course, you will place your SPORTident stick in to the finish station to stop your time. You will then again be asked your HR, RPE and discomfort. We will then record your weight and you will return your testing equipment and any additional weight you were given.

There will be medics and support staff along the course if you require assistance. Your safety and well-being is of utmost importance to us. If you are injured, stop and see a medic. If you choose to discontinue the march for any reason other than a medical emergency, please return to the finish line to checkout. We need to determine your reason for stopping, the distance you completed, and collect the equipment from you.

Again, please walk as quickly as you can, but remember, you should be able to complete your mission at the end of the four miles. Do not jog or do the airborne shuffle. Do you have any questions?

**Prepare a Fighting Position (Emplace Sandbags)**

*Participant Instructions:*

The purpose of this task is to determine the reliability of carrying and emplacing 16 filled sandbags as quickly as possible. Before we get started, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. When I say go, you will carry a total of 16 sandbags 10 meters where you will build a fighting position that is 4 sandbags wide, 2 sandbags deep, and 2 sandbags tall. You may carry no more than 2 sandbags at a time, and you must properly place the sandbags you are carrying within the marked outline before returning for the next bag. Upon completion of the task, you will rate how hard you worked using the scale from 6-20 (show scale, read instructions). You should move as quickly as you can to complete the task while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

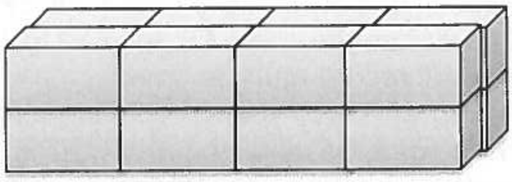


Figure A. Design of fighting position.

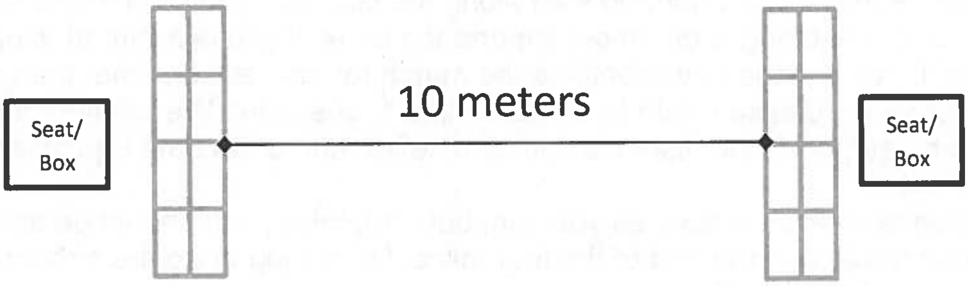



Figure B. Overhead layout.

***Drag a Casualty to Safety***

The purpose of this task is to determine reliability of quickly dragging a 270-lb casualty a distance of 15 meters. Before we get started, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. When told to begin, you will grasp the harness on the dummy with one or two hands and drag it as quickly as possible past the 2nd set of cones. The feet of the dummy must cross the line before you stop, so don't stop until I tell you to. You will have 30 seconds to complete this task and I will count down the last 5 seconds and say 'stop'. If you cross the finish line within 30s, I'll tell you when to stop. If you do not cross the finish line when I count down and say 'stop', stop right where you are and wait until I tell you to release the dummy. I will measure how far you dragged it. Upon completion of the task, we will record your heart rate and you will rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions).

You should perform the task as quickly as you can while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Before we start the test, you will drag the dummy a few feet to get a feel for the weight. Do you have any questions?

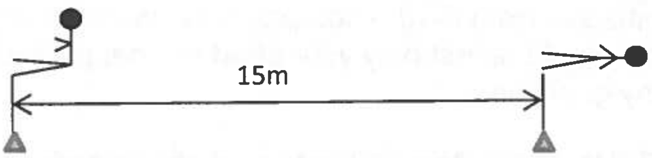



Figure A. If completed task (Record 15m and actual completion time)

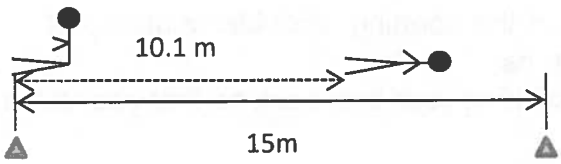



Figure B. If task not completed (Record 30 seconds & Distance to feet)

***Remove a Casualty from a Vehicle***

*Participant Instructions:*

The purpose of this test is to determine the reliability of a maximal heavy lift test designed to mimic removing a casualty from a vehicle. The weight of the bag will begin at 50 lbs. You will squat, grasp the shoulder straps and pull the bag out through the hole simulating the commander's hatch. You must lift the bag up and place it beside the hatch (either upright or on its side) for it to be considered successful. Everyone will complete this weight so that we can ensure you are using the proper lifting technique. After everyone has completed the first weight, an additional 10 lbs will be added to the bag, and we will cycle through everyone again. You may choose to skip up to 2 consecutive weight increments if you feel confident you can complete it; however, the tester may ask you to perform the weight anyway. The maximum lift for this test is 210 lbs.

Make sure you are wearing gloves. Prior to starting we will review proper lifting technique using a set of kettlebells. You will be required to use good technique to protect your lower back. If you show poor lifting technique, we will stop you and you will not receive credit for that weight. If you feel any pain or discomfort, you should release the bag and stop performing the task.

Upon completion of each lift, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, review instructions before test begins). Your rating should reflect only your effort for that particular weight.

Do you have any questions?

PROPER LIFTING TECHNIQUE: ***Demonstrate and check before testing***

*Starting position:*

- Place feet at edge of the opening, shoulder width apart
- Knees in line with toes
- Bend at the hips, sticking your butt back so that your *back is flat or slightly arched*
- Head up
- Grip the bag with arms fully extended.

*Motion:*

- Pull the bag straight up by extending the knees and hips at the same time. The bag should stay as close to your legs as possible.
- Arms should remain extended until knees and hips are fully extended.
- Extend your knees and hips fully before you use your arms to lift and tilt the bag out of the opening. Once upright, you are allowed to bend your knees again to finish the lift if necessary

If you do not use correct form, the test will be stopped. Poor form includes:

- Arching or rounding your back during the lift
- Holding your breath. You should exhale while lifting

## APPENDIX K. QUESTIONNAIRES AND SURVEYS FROM STUDY 2

**Physical Performance Standards Study**

**Demographics Sheet**

Subject ID__________

Sex _____________

Age _____________

Date of Birth: _______________

**(To be filled out by investigator)**

Height (in)

__________

ACU Unloaded (lbs)

__________

Fighting Load minus Weapon (lbs)

__________

Fighting Load (lbs)

__________

Approach March Load (lbs)

__________

Race (circle one):

Caucasian African American Hispanic Asian

MOS ____________ Rank _______________

Last Army Physical Fitness Test Score (total) _____________

Push-ups (reps) _____________

Sit-ups (reps) ______________

2-Mile Run Time (min:sec) _____________

MOS – 12B

**Demographic Data: Please complete the following items.**

Subject ID_____________

Total time of military service (years) ______________

Total time in current MOS (years) ________________

Total time deployed in current MOS (months) ___________

Deployment locations:_____________ ____________ ______________

**Directions: Please indicate whether you have performed these tasks in training or while deployed and the number of times you have performed them in each setting.**

| | | *Performed During* | | | |
|---|---|---|---|---|---|
| | | *Training* | | *Deployed* | |
| *Master Task Number/Master Task* | | *(Y/N)* | *# of times* | *(Y/N)* | *# of times* |
| *1* | *Conduct a tactical movement* | | | | |
| *2* | *Employ hand grenades* | | | | |
| *3* | *Carry Sandbags to build a fighting position* | | | | |
| *4a* | *Drag casualty to safety (dismounted)* | | | | |
| *4b* | *Remove casualty from a vehicle (mounted)* | | | | |
| *5* | *Lift, carry, and install the barrel of a 25mm gun* | | | | |
| *6* | *Remove the feeder assembly of a 25mm gun* | | | | |
| *7* | *Load 25mm H-EIT tracer ammunition cans* | | | | |
| *27* | *Carry and emplace the APOBS* | | | | |
| *28* | *Carry and emplace the H6 cratering charge* | | | | |
| *29* | *Carry the Modular-Pack Mine System* | | | | |
| *30* | *Lift and carry rocking roller for Bailey Bridge* | | | | |
| *31* | *Load and install a Volcano* | | | | |

Subject ID: ____________ Date/Time: ____________________

**USARIEM MOS Physical Performance Standards Study**
**Reliability Phase**

## Sandbag Carry

**Test Repetition Number:** 1 2 3 4
*(Circle one)*

**Soldier Weight**
***Fighting Load NO WEAPON* (lbs):** ______________

**Stopwatch Number:** _________ **Stopwatch Record #:** ______________

| *Time to Finish (Min:Sec)* | *RPE (6-20)* | *Pre HR (bpm)* | *Post HR (bpm)* |
|---|---|---|---|
| ___ : ___ | | | |

| *Bag Number* | *Time (min:sec)* |
|---|---|
| 1 | : |
| 2 | : |
| 3 | : |
| 4 | : |
| 5 | : |
| 6 | : |
| 7 | : |
| 8 | : |

| *Bag Number* | *Time (min:sec)* |
|---|---|
| 9 | : |
| 10 | : |
| 11 | : |
| 12 | : |
| 13 | : |
| 14 | : |
| 15 | : |
| 16 | : |

**Comments:**

**Test Administrator's Initials** __________

Subject ID: ____________ Date/Time: ____________________

**USARIEM MOS Physical Performance Standards Study**
**Reliability Phase**

# Casualty Drag

**Test Repetition Number:** 1 2 3 4
*(Circle one)*

**Soldier Weight**
*Fighting Load WITH WEAPON* **(lbs):** ________________

| *Distance (m)* | *Time (sec)* | *Velocity (m/s)* |
|---|---|---|
| | | |

| *RPE (0-10)* | *Pre HR (bpm)* | *Final HR (bpm)* |
|---|---|---|
| | | |

**Comments:**

**Test Administrator's Initials** ____________

Subject ID: ____________ Date/Time: ____________________

**USARIEM MOS Physical Performance Standards Study**
**Reliability Phase**

## Casualty Extraction

**Test Repetition Number:** 1 2 3 4
*(Circle one)*

**Soldier Weight**
***Fighting Load NO WEAPON* (lbs):** ________________

| *Rep* | *Bag Weight (lbs)* | *Completed (Y/N)* | *RPE (0-10)* |
|---|---|---|---|
| 1 | | | |
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**Comments:**

**Test Administrator's Initials** ____________

Date: ____________ Data Collector: ______________

Test Repetition Number: 1 2 3 4

## USARIEM MOS Physical Performance Standards Study

### Tactical Road March: Start Data Sheet

| Subject # | Start Time | HR |
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Page ____ of ____

Date: ______________ Data Collector: ________________

Test Repetition Number: 1 2 3 4

## USARIEM MOS Physical Performance Standards Study

## Tactical Road March: Finish Data Sheet

| Subject # | Finish Time | RPE | HR |
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Page ____ of ____

Date: ______________ Data Collector: ________________

Test Repetition Number: 1 2 3 4

USARIEM MOS Physical Performance Standards Study

Tactical Road March: Checkpoint Data Sheet

| Subject # | Check-in Time | RPE | HR |
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Page ____ of ____

**USARIEM MOS Physical Performance Standards Study**
**Tactical Road March: Start Discomfort Scale**

Date: ____________ Data Collector: ______________

Test Repetition Number: 1 2 3 4

| Subject ID | 1 Neck | 2 Left Shoulder | 3 Right Shoulder | 4 Left Upper Arm | 5 Right Upper Arm | 6 Left Forearm | 7 Right Forearm | 8 Left Wrist | 9 Right Wrist | 10 Left Hand | 11 Right Hand | 12 Upper Back | 13 Mid/Lower Back | 14 Hips/Waist | 15 Buttocks | 16 Left Thigh | 17 Right Thigh | 18 Knees | 19 Left Leg/Foot | 20 Right Leg/Foot | 21 Ankles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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Page ___ of ___

**USARIEM MOS Physical Performance Standards Study**
**Tactical Road March: Finish Discomfort Scale**

Date: ____________ Data Collector: ______________

Test Repetition Number: 1 2 3 4

| Subject ID | 1 Neck | 2 Left Shoulder | 3 Right Shoulder | 4 Left Upper Arm | 5 Right Upper Arm | 6 Left Forearm | 7 Right Forearm | 8 Left Wrist | 9 Right Wrist | 10 Left Hand | 11 Right Hand | 12 Upper Back | 13 Mid/Lower Back | 14 Hips/Waist | 15 Buttocks | 16 Left Thigh | 17 Right Thigh | 18 Knees | 19 Left Leg/Foot | 20 Right Leg/Foot | 21 Ankles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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## APPENDIX L. TASK INSTRUCTIONS FROM STUDY 3

### *Foot March:*

The purpose of this task is to determine the relationship between performance on a 4-mile roadmarch and simple predictor tests. You will walk as quickly as you can for 4 miles while carrying total load of 103 lbs. While this task should be completed quickly, do not run. Choose a pace that you can maintain and that would allow you to maintain situational awareness to complete a mission. You may take any rest time that you need, but try to finish as quickly as you can.

At the start, you will be asked your HR and current level of discomfort (show discomfort scale and read instructions). You will then place the SPORTident stick in the clear station followed by the start station. When it beeps, your time will begin. At the midpoint, there will be a tester who will ask your HR and RPE (using the 6-20 scale, read instructions if necessary). Respond as quickly as possible, then check out using the other control station and continue on the course. There will be a cone and a stake at the end of each ½ mile. Please walk between the two. Your SPORTident stick will beep as you pass between the marker and the cone. Do not rest within 50 feet of these markers, because the system will record multiple times.

At the end of the course, you will place your SPORTident stick in to the finish station to stop your time. You will then again be asked your HR, RPE and discomfort. We will then record your weight and you will return your testing equipment and any additional weight you were given.

There will be medics and support staff along the course if you require assistance. Your safety and well-being is of utmost importance to us. If you are injured, stop and see a medic. If you choose to discontinue the march for any reason other than a medical emergency, please return to the finish line to checkout. We need to determine your reason for stopping, the distance you completed, and collect the equipment from you.

Again, please walk as quickly as you can, but remember, you should be able to complete your mission at the end of the four miles. Do not jog or do the airborne shuffle. Do you have any questions?

***Sandbag Carry***

The purpose of this task is to determine the relationship between performance of carrying and emplacing 16 filled sandbags as quickly as possible and simple predictor tests. Before we get started, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. When I say go, you will carry a total of 16 sandbags 10 meters where you will build a fighting position that is 4 sandbags wide, 2 sandbags deep, and 2 sandbags tall. You may carry no more than 2 sandbags at a time, and you must properly place the sandbags you are carrying within the marked outline before returning for the next bag. Upon completion of the task, you will rate how hard you worked using the scale from 6-20 (show scale, read instructions). You should move as quickly as you can complete the task while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

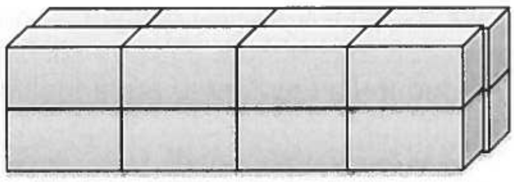

Figure A. Design of fighting position.

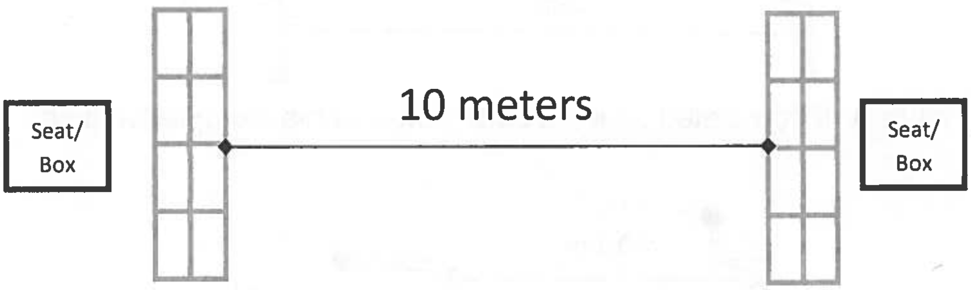


Figure B. Overhead layout.

*Casualty Drag*

The purpose of this task is to determine the relationship between performance of dragging a 270-lb casualty a distance of 15 meters and simple predictor tests. Before we get started, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. When told to begin, you will grasp the harness on the dummy with one or two hands and drag it as quickly as possible past the 2nd set of cones. The feet of the dummy must cross the line before you stop, so don't stop until I tell you to. You will have 30 seconds to complete this task and I will count down the last 5 seconds and say 'stop'. If you cross the finish line within 30s, I'll tell you when to stop. If you do not cross the finish line when I count down and say 'stop', stop right where you are and wait until I tell you to release the dummy. I will measure how far you dragged it. Upon completion of the task, we will record your heart rate and you will rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions).

You should perform the task as quickly as you can while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Before we start the test, you will drag the dummy a few feet to get a feel for the weight. Do you have any questions?

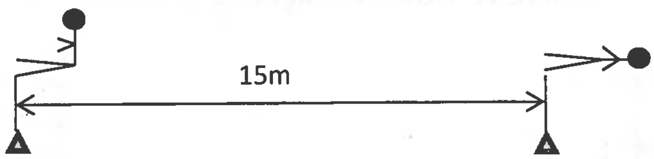


Figure A. If completed task (Record 15m & actual completion time)

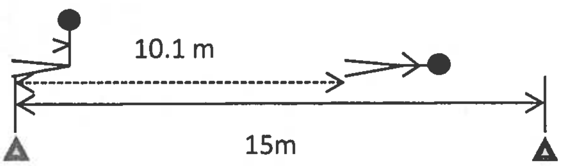


Figure B. If task not completed (Record 30 seconds & Distance to feet)

***Casualty Evacuation***

The purpose of this task is to determine the relationship between performance of a maximal heavy lift test designed to mimic removing a casualty from a vehicle, and simple predictive tests. The weight of the bag will begin at 50 lbs. You will squat, grasp the shoulder straps and pull the bag out through the hole simulating the commander's hatch. You must lift the bag up and place it beside the hatch (either upright or on its side) for it to be considered successful. Everyone will complete this weight so that we can ensure you are using the proper lifting technique. After everyone has completed the first weight, an additional 10 lbs will be added to the bag, and we will cycle through everyone again. You may choose to skip up to 2 consecutive weight increments if you feel confident you can complete it; however, the tester may ask you to perform the weight anyway. The maximum lift for this test is 210 lbs.

Make sure you are wearing gloves. Prior to starting we will review proper lifting technique using a set of kettlebells. You will be required to use good technique to protect your lower back. If you show poor lifting technique, we will stop you and you will not receive credit for that weight. If you feel any pain or discomfort, you should release the bag and stop performing the task.

Upon completion of each lift, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, review instructions before test begins). Your rating should reflect only your effort for that particular weight.

Do you have any questions?

PROPER LIFTING TECHNIQUE: ***Demonstrate and check before testing***

*Starting position:*

- Place feet at edge of the opening, shoulder width apart
- Knees in line with toes
- Bend at the hips, sticking your butt back so that your *back is flat or slightly arched*
- Head up
- Grip the bag with arms fully extended.

*Motion:*

- Pull the bag straight up by extending the knees and hips at the same time. The bag should stay as close to your legs as possible.
- Arms should remain extended until knees and hips are fully extended.
- Extend your knees and hips fully before you use your arms to lift and tilt the bag out of the opening. Once upright, you are allowed to bend your knees again to finish the lift if necessary

If you do not use correct form, the test will be stopped. Poor form includes:

- Arching or rounding your back during the lift.
- Holding your breath. You should exhale while lifting.

**Beep Test**

The purpose of this task is to determine the ability of the beep test to predict performance of the physically demanding tasks of a 12B. You will jog, run, and then sprint continuously between the two lines 20 meters apart in time to recorded beeps. This test will require that you push yourself to your maximal ability and you should be winded at the end of the test. The audio recording will tell you when to begin. The test start begins with a slow warmup. The beeps will increase in speed every level, which is about every minute. This will be indicated on the audio recording with a different sound. Each shuttle within a level is at the same speed.

You must cross the opposite line before the beep occurs and you cannot leave the line until the beep sounds. If you do not make it to the line before the beep, I will call out your ID number and give you a warning (Example: "352, warning #1"; "352, warning #2"). When you miss 3 beeps *in a row*, you will be informed by the investigator that the test is over ("352, you're done!"). At any point, you may choose to stop on your own if you do not feel like you can continue.

After completing, an investigator will ask you to read your heart rate off of your heart rate monitor. Do you have any questions?

**Standing Long Jump**

The purpose of this task is to determine the ability of the standing long jump to predict performance of the physically demanding tasks of a 12B. You will stand behind the line with your feet slightly apart. You will jump as far as possible with a two-foot take-off and landing. You are allowed to swing your arms and bend your knees to provide forward push. If you fall, we will ask you to repeat the attempt. You will be given two practice jumps and then you will perform three maximal effort jumps that will be recorded. Do you have any questions?

**38cm Upright Pull**

The purpose of this task is to determine the ability of an upright pull to predict performance of the physically demanding tasks of a 12B. You will stand with your feet about 50 cm apart, and squat down flexing at the knees and hips. You will grasp the handles with the palms facing in opposite direction approximately equidistant from the center of the handle. Then place your buttocks against the wall to the rear, and straighten your back and look straight ahead. I will give you a "ready-three-two-one-pull," without jerking build up to your maximal force in about 2 seconds, maximally pull for about 3 more seconds and then relax. You will perform the test three times, if you improperly performed the test you will be asked to take a short rest and repeat the attempt. Do you have any questions?

**Isometric Biceps Curl**

The purpose of this task is to determine the ability of an isometric biceps curl to predict performance of the physically demanding tasks of a 12B. You will stand holding onto a bar with palms facing up, elbows at right angle and forearms parallel to the floor. I will adjust the instrument to fit you. You will stand with your feet hip width apart without bending your knees or hips. I will give you a "ready-three-two-one-pull," without jerking or leaning back, build up to your maximal force in about 2 seconds, pull for about 3 more seconds and then relax. You will perform the test three times, if you improperly performed the test you will be asked to take a short rest and repeat the attempt. Do you have any questions?

**2-Minute Arm Ergometer**

The purpose of this task is to determine the ability of an arm ergometers test to predict performance of the physically demanding tasks of a 12B. The test involves cranking an Arm Ergometer, as fast as possible, for two minutes. You will kneel in front of the arm ergometer and I will adjust the handles to fit you. After, you will perform 10 revolutions to familiarize yourself with the test and to provide a warm up. When you are ready I will say "ready-three-two-one-GO," you will then have two minutes to perform as many revolutions as possible. We will inform you when you are half way, and when you have 30 and 15 seconds left. We will record the number of revolutions at 2 minutes. Do you have any questions?

**Loaded Step Test**

The purpose of this task is to determine the ability of a loaded step test to predict performance of the physically demanding tasks of a 12B. Before we get started, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. When told to begin, you will step up and down from the step to the beat of the metronome. You will complete an UP, UP, DOWN, DOWN motion (demonstrate and practice) with one foot movement on every beat. You should complete the cycle every 4 beats.

The test will end after you fail to keep the pace for two consecutive cycles or after a maximum of 5 minutes. I will be asking for your heart rate periodically during the task and for 1-minute after you finish.

You should perform the task as long as you can while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

**Handgrip**

The purpose of this task is to determine the ability of handgrip strength to predict performance of the physically demanding tasks of a 12B. The base of the handle will be set so it rests on the heel of the palm and the handle will rest on the middle of the four fingers. You will then hold it so that your elbow is flexed to 90 degrees, the device is oriented up and down, and your shoulder and wrist are in a relaxed position. When I say go, you will squeeze your hand as tight as possible, while avoiding use of any other part of the body. If I see that you are using other muscles, you will be asked to repeat the measure. You repeat this 3 times in each hand, alternating hands.

Do you have any questions?

**One Minute Sit-Up**

The purpose of this task is to determine the ability of using a 1-minute sit-up score to predict performance of the physically demanding tasks of a 12B. You will begin by lying down in the proper sit-up position. You should be lying on your back with your knees bent at a 90-degree angle. Place your feet under the tables at the end of the mat. During the test, your fingers must be interlocked behind your head and the backs of your hands must touch the ground. On the command "Go" you should begin raising your upper-body forward to the vertical position. After reaching the vertical position, you should lower-body until the bottom of your shoulder blades touch the ground. You must use proper sit-up technique for the repetition to count. If you need to rest, you may do so only in the up position without resting your arms on your legs to hold yourself up. You may not rest in the down position. You will have 1-minute to complete as many as possible.

You should perform the task as long as you can while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

**One Minute Push-Up**

The purpose of this task is to determine the ability of using a 1-minute push-up score to predict performance of the physically demanding tasks of a 12B. You will begin by assuming a front-leaning rest position by placing your hands shoulder-width apart, with your feet together or up to 12 inches apart. When I say "Go", you should begin the push-up by bending your elbows and lowering your entire body as a single unit until your upper arms are at least parallel to the ground. Then, you should return to the starting position by raising your entire body until your arms are fully extended. At the end of each repetition, the scorer will state the number of push-ups correctly performed. Push -ups in which the arms are not parallel to the ground or the elbows are not fully locked at the end of a repetition will not be scored. You may rest at any time, however during rest breaks your hands and feet must not break contact with the ground. You will have 1-minute to complete as many as possible.

You should perform the task as long as you can while maintaining your safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

**Illinois Agility Test**

The purpose of this test is to assess the ability of the Illinois agility test to predict performance of the physically demanding tasks of a 12B. During this test, you will run through a series of cones. (*Show Soldiers figure below, and point out the course as you explain the next section*). You will start the test lying on your stomach with your hands in a push-up position and facing the first far cone. I will give you a "three-two-one-go" and you will sprint to the far cone, then sprint back to this middle cone (point to it). Do a zig-zag up and back in the center cones. Sprint to the far cone (point to it) and then sprint back through the finish line (point to it). During the test, run through the course as fast as you can, while maintaining safety and without knocking over the cones. If at any point you feel you are unable to continue, the test will be terminated. If you make a mistake during the test we will ask you to stop and repeat the attempt.

Do you have any questions?

If you wouldn't mind following me, I will walk you through the course before we begin.

**300m Sprint**

The purpose of this test is to assess the ability of the 300 meter sprint test to predict performance of the physically demanding tasks of a 12B. You will start the test with the toes of one foot on the starting line, and the other foot either even with or behind the line. When I say go, you will run 300 meters. The test is complete when you cross the finish line. Run the 300 meters as fast as you can, while maintaining safety. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

**Medicine Ball Throw**

The purpose of this test is to assess the ability of the medicine ball throw test to predict performance of the physically demanding tasks of a 12B. During the test, you will sit in the chair with your back against the back rest and both feet on the ground. During throw and follow through your back must stay in contact with the chair. You will hold the medicine ball with both hands. When I say go, you will touch the medicine ball to your chest and then push/throw it as far forward as possible. It is recommended that you throw it up at a 45° angle to get maximum distance. The distance between the front of the chair and the landing point of the medicine ball will be measured. You will be given two practice throws. After the practice throws you will be asked to complete three throws for record. While throwing the medicine ball, you must keep your back against the chair. If you fail to maintain contact with the back of the chair you will be asked to repeat the throw. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

## APPENDIX M. QUESTIONNAIRES AND SURVEYS FROM STUDY 3

(To be filled out by investigator)

Height (in) ________

ACU Unloaded (lbs) ________

Fighting Load minus Weapon (lbs) ________

Fighting Load (lbs) ________

Approach March Load (lbs) ________

**Physical Performance Standards Study**

**Ft Hood, TX July 2014**

**Demographics Sheet**

Subject ID__________

Sex ____________

Age ____________ Date of Birth: ____________

Race (circle one):

Caucasian African American Hispanic Asian

MOS ____________ Rank ______________

Last Army Physical Fitness Test Score (total) ____________

Push-ups (reps) ____________

Sit-ups (reps) ____________

2-Mile Run Time (min:sec) ____________

**MOS – 12B**

**Demographic Data: Please complete the following items.**

Subject ID______________

Total time of military service (years) ______________

Total time in current MOS (years) ________________

Total time deployed in current MOS (months) ___________

Deployment locations:______________ ____________ ______________

**Directions: Please indicate whether you have performed these tasks in training or while deployed and the number of times you have performed them in each setting.**

| *Master Task Number/Master Task* | | *Performed During* | | | |
|---|---|---|---|---|---|
| | | *Training (Y/N)* | *# of times* | *Deployed (Y/N)* | *# of times* |
| *1* | *Conduct a tactical movement wearing a fighting load* | | | | |
| *2* | *Employ hand grenades* | | | | |
| *3* | *Prepare a fighting position* | | | | |
| *4a* | *Drag casualty to safety (dismounted)* | | | | |
| *4b* | *Remove casualty from a vehicle (mounted)* | | | | |
| *5* | *Lift, carry, and install the barrel of a 25mm gun* | | | | |
| *6* | *Remove the feeder assembly of a 25mm gun* | | | | |
| *7* | *Load 25mm H-EIT tracer ammunition cans* | | | | |
| *27* | *Carry and emplace the APOBS* | | | | |
| *28* | *Carry and emplace the H6 cratering charge* | | | | |
| *29* | *Carry the Modular-Pack Mine System* | | | | |
| *30* | *Lift and carry rocking roller for Bailey Bridge* | | | | |
| *31* | *Load and install a Volcano* | | | | |

Subject ID: ____________ Date: ____________________

## USARIEM MOS Physical Performance Standards Study
## 12B Predictive Tasks

Weight in PT Uniform: ______________

| | *Level #* | *Shuttle #* | *Pre HR* | *Post HR* |
|---|---|---|---|---|
| Beep Test | | | | |

**Comments:**

| | # |
|---|---|
| One Minute Sit Ups | |
| One Minute Push Ups | |

**Comments:**

| | *Minute 1 (revs)* | *Minute 2 (revs)* | *Pre HR* | *Post HR* |
|---|---|---|---|---|
| Arm Endurance Test | | | | |

| | *Trial 1* | *Trial 2* | *Trial 3* |
|---|---|---|---|
| Standing Broad Jump (m) | | | |

**Comments:**

Revised 19JUN2014

Subject ID: ____________ Date: ________________

## USARIEM MOS Physical Performance Standards Study
## 12B Predictive Tasks

| | *Timer 1 (Start Line)* | *Timer 2 (Finish Line)* |
|---|---|---|
| **300 Meter Run** (min:sec) | : | : |

| | *Left 1* | *Left 2* | *Left 3* |
|---|---|---|---|
| **Handgrip (kg)** | | | |
| | *Right 1* | *Right 2* | *Right 3* |
| | | | |

**Comments:**

---

| | *Trial 1* | *Trial 2* | *Trial 3* |
|---|---|---|---|
| **Medicine Ball Put** (cm) | | | |
| **Illinois Agility** (min:sec) | : | | |

**Comments:**

---

| | *Trial 1* | *Trial 2* | *Trial 3* |
|---|---|---|---|
| **Upright Pull (unit)** | | | |
| **Isometric Bicep Curl (unit)** | | | |

**Comments:**

Revised 19JUN2014

Subject ID: ____________ Date: ____________________

USARIEM MOS Physical Performance Standards Study

12B Criterion Tasks

# Sandbag Carry

**Soldier Weight**
***Fighting Load NO WEAPON* (lbs): ______________**

**Stopwatch Number: _________ Stopwatch Record #: ______________**

| *Time to Finish (Min:Sec)* | *RPE (6-20)* | *Pre HR (bpm)* | *Post HR (bpm)* |
|---|---|---|---|
| ___ : ___ | | | |

| *Bag Number* | *Time (min:sec)* |
|---|---|
| 1 | : |
| 2 | : |
| 3 | : |
| 4 | : |
| 5 | : |
| 6 | : |
| 7 | : |
| 8 | : |

| *Bag Number* | *Time (min:sec)* |
|---|---|
| 9 | : |
| 10 | : |
| 11 | : |
| 12 | : |
| 13 | : |
| 14 | : |
| 15 | : |
| 16 | : |

**Comments:**

# Loaded Step Test

**Soldier Weight**
***Fighting Load WITH WEAPON* (lbs):**

| *Time (min:sec)* | *Pre Heart Rate* | *Test Period Heart Rate* | | | |
|---|---|---|---|---|---|
| | | 1 Min | 2 Min | 3 Min | 4 Min |
| : | | | | | |

| *End Heart Rate* | *Post Test Heart Rate* | | | |
|---|---|---|---|---|
| | 15 Sec | 30 Sec | 45 Sec | 60 Sec |
| | | | | |

**Comments:**

Revised 19JUN2014

Subject ID: ____________ Date: ____________________

USARIEM MOS Physical Performance Standards Study

12B Criterion Tasks

# Casualty Extraction

Soldier Weight

*Fighting Load NO WEAPON* (lbs): ______________

| *Rep* | *Bag Weight (lbs)* | *Completed (Y/N)* | *RPE (0-10)* |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
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| 7 | | | |
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**Comments:**

# Casualty Drag

Soldier Weight

*Fighting Load WITH WEAPON* (lbs): ______________

| *Distance (m)* | *Time (sec)* | *RPE (0-10)* | *Pre HR (bpm)* | *Final HR (bpm)* |
|---|---|---|---|---|
| | | | | |

**Comments:**

Revised 19JUN2014

USARIEM

Date: ____________ Data Collector: ______________

**USARIEM MOS Physical Performance Standards Study**

**Tactical Road March: Start Data Sheet**

| Subject # | Start Time | HR |
|---|---|---|
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Page ____ of ____

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Date: ______________ Data Collector: ________________

**USARIEM MOS Physical Performance Standards Study**

**Tactical Road March: Finish Data Sheet**

| Subject # | Finish Time | RPE | HR |
|---|---|---|---|
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Page ____ of ____

**USARIEM MOS Physical Performance Standards Study**
**Tactical Road March: Start Discomfort Scale**

Date: ____________ Data Collector: ______________

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject ID | Neck | Left Shoulder | Right Shoulder | Left Upper Arm | Right Upper Arm | Left Forearm | Right Forearm | Left Wrist | Right Wrist | Left Hand | Right Hand | Upper Back | Mid/Lower Back | Hips/Waist | Buttocks | Left Thigh | Right Thigh | Knees | Left Leg/Foot | Right Leg/Foot | Ankles |
| | | | | | | | | | | | | | | | | | | | | | |
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Page ____ of ____

**USARIEM MOS Physical Performance Standards Study**
**Tactical Road March: Finish Discomfort Scale**

Date: ____________ Data Collector: ______________

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject ID | Neck | Left Shoulder | Right Shoulder | Left Upper Arm | Right Upper Arm | Left Forearm | Right Forearm | Left Wrist | Right Wrist | Left Hand | Right Hand | Upper Back | Mid/Lower Back | Hips/Waist | Buttocks | Left Thigh | Right Thigh | Knees | Left Leg/Foot | Right Leg/Foot | Ankles |
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## APPENDIX N. ADDITIONAL STATISTICAL TABLES FROM STUDY 3

*Pearson Correlations Among Criterion Tasks*

| | Foot March | Sandbag Carry | Casualty Evacuation | Casualty Drag |
|---|---|---|---|---|
| **Foot March** | -- | 0.572** | -0.556** | -0.521** |
| **Sandbag Carry** | 0.572** | -- | -0.772** | -0.732** |
| **Casualty Evacuation** | -0.556** | -0.772** | -- | 0.775** |
| **Casualty Drag** | -0.521** | -0.732** | 0.775** | -- |

**p<0.01; *p<0.05

*Pearson Correlations Among Predictor Tests*

| | Step Test | Beep Test | Sit-up | Push-up | AE[1] | SLJ[2] | 300m Run | Hand Grip | Med Ball Put | Illinois Agility | Upright Pull | Biceps Curl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Step Test** | -- | 0.666** | 0.390** | 0.563** | 0.523** | 0.517** | -0.633** | 0.409** | 0.429** | -0.410** | 0.443** | 0.437** |
| **Beep Test** | 0.666** | -- | 0.349** | 0.630** | 0.551** | 0.566** | -0.688** | 0.477** | 0.450** | -0.450** | 0.424** | 0.483** |
| **Sit-up** | 0.390** | 0.349** | -- | 0.400** | 0.185* | 0.268** | -0.287** | 0.129 | 0.071 | -0.162 | 0.181* | 0.164* |
| **Push-up** | 0.563** | 0.630** | 0.400** | -- | 0.614** | 0.548** | -0.561** | 0.545** | 0.557** | -0.428** | 0.572** | 0.687** |
| **AE[1]** | 0.523** | 0.551** | 0.185* | 0.614** | -- | 0.712** | -0.643** | 0.790** | 0.779** | -0.489** | 0.769** | 0.797** |
| **SLJ[2]** | 0.517** | 0.566** | 0.268** | 0.548** | 0.712** | -- | -0.728** | 0.684** | 0.771** | -0.661** | 0.729** | 0.739** |
| **300m Sprint** | -0.633** | -0.688** | -0.287** | -0.561** | -0.643** | -0.728** | -- | -0.583** | -0.622** | 0.545** | -0.633** | -0.594** |
| **Handgrip** | 0.409** | 0.477** | 0.129 | 0.545** | 0.790** | 0.684** | -0.583** | -- | 0.788** | -0.523** | 0.809** | 0.814** |
| **Med Ball Put** | 0.429** | 0.450** | 0.071 | 0.557** | 0.779** | 0.771** | -0.622** | 0.788** | -- | -0.533** | 0.821** | 0.856** |
| **Illinois Agility** | -0.410** | -0.450** | -0.162 | -0.428** | -0.489** | -0.661** | 0.545** | -0.523** | -0.533** | -- | -0.549** | -0.518** |
| **Upright Pull** | 0.443** | 0.424** | 0.181* | 0.572** | 0.769** | 0.729** | -0.633** | 0.809** | 0.821** | -0.549** | -- | 0.859** |
| **Biceps Curl** | 0.437** | 0.483** | 0.164* | 0.687** | 0.797** | 0.739** | -0.594** | 0.814** | 0.856** | -0.518** | 0.859** | -- |

**p<0.01; *p<0.05
[1] 2-Minute Arm Ergometer
[2] Standing Long Jump