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14. ABSTRACT

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 19 Series Armor. 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 most physically demanding tasks: casualty evacuation (19D & 19K), casualty drag (19D & 19K), foot march (19D & 19K), move under fire (19D & 19K), sandbag carry (19D), stow ammo on an Abrams (19K), and load the main gun of an Abrams (19K). In the final study, screening batteries using basic predictor tests for each MOS were developed to fit a range of needs of the Army.

15. SUBJECT TERMS

Armor, Predictive Testing, OPAT, Physical Demands, M1 Armor Crewman, Cavalry Scout

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USARIEM TECHNICAL REPORT T16-7

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FOREWORD

This Technical Report is the first in a series documenting the development of a physical employment screening test for 7 Combat Arms Military Occupational Specialties (MOSs) as part of the Soldier 2020 initiative. The models presented herein are developed specifically using information from the 19 Series studies. Additional reports describe the studies on the Combat Engineers (12B) Field Artillery (13B, 13F), and Infantry (11B, 11C) MOSs. Portions of the data presented herein were also reported in the technical reports for those 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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LIST OF ACRONYMS

ACH	Advanced Combat Helmet
ACU	Army Combat Uniform
AIT	Advanced Individual Training
AOC	Area of Concentration
APFT	Army Physical Fitness Test
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
HEI-T	High Explosive Incendiary Tracer
HR	Heart Rate
IOTV	Improved Outer Tactical Vest
MEPS	Military Entrance Processing Station
MPAT	Multi-Purpose Anti-Tank
MOS	Military Occupational Specialty
OCOA	Office of the Chief of Armor
OSUT	One Station Unit Training
PPE	Personal Protective Equipment
RPE	Rate of Perceived Exertion
SME	Subject Matter Expert
TRADOC	Training and Doctrine Command
TOW	Tube-Launched, Optically-Tracked, Wire-Guided
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 (34). 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 ability 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 two minutes, number of sit-ups performed in two minutes, and time to complete a 2-mile 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 (17, 23). 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 (13). 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.

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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. Protocol # 9300.

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Portions of the data presented in this report have been previously reported.

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) develop criterion-based physical requirements for entry into seven physically demanding combat MOSs, including the 19D Cavalry Scouts and 19K M1 Armor Crewman.

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 March 2014, involved measuring and identifying the physiological requirements of each of the tasks of the MOS in order to identify a set of criterion task encompassing the physical demands of all of the jobs of the MOS. From these data, as well as incorporating data from focus groups, casualty evacuation, casualty drag, sandbag carry (19D only), stow ammo (19K only), load the main gun (19K only) and foot march were identified as representative of all heavy lift, heavy drag, lift and carry, and load carriage tasks. These tests were vetted by SMEs, who also requested an additional test be added: move under direct fire.

With these criterion tasks were 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 and December 2014, involved developing task simulations of these tasks. All 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, April-June 2015). Five models for each MOS were proposed to fit a range of needs of the Army (i.e., cost and space requirements). Potential predictor tests included squat lift, standing long jump, beep test, medicine ball put, arm ergometer, resistance pull, 1-minute sit-up, 1-minute push-up, Illinois agility test, and 300m sprint.

With the 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: Additional technical reports detail studies for the Combat Engineers, Field Artillery, and Infantry MOSs. A final report will be written to develop one overarching test battery of five to seven tests to cover all seven Combat Arms MOSs. This final test battery may be slightly different than those presented here, as the model will be optimized for all seven MOSs collectively.

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 of interest (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 relevant 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.

For the next phase of the study, USARIEM researchers 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 the 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 (20).

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 responses were collected from members of each of the MOSs. These measurements included heart rate, rate of perceived exertion, and metabolic cost. In addition to male 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.

Both the 19D Cavalry Scouts and 19K M1 Armor Crewman MOSs are included in the highest level (very heavy) of physical demands. Cavalry Scouts aid in reconnaissance, security, routing, and other combat operations. Armor Crewman serve as a member of an M1 unit, performing offensive and defensive operations with the Abrams tank. 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. Stewart, GA during March 2014 from Soldiers of the 2nd Armored Brigade Combat Team, 3rd Infantry Division. Two cohorts of males and females were recruited to complete the tasks of the either the 19D or 19K MOS. Physiological measurements were collected on 23 males with MOS 19D and 15 females from other MOSs/AOCs (42A, 91A, 25B, 89B, 92G, 91H, 88M, 68W, 1 unknown) while performing the 19D Cavalry Scout tasks. Measurements were collected from 23 males with MOS 19K and a separate set of 15 females (MOSs: 92A, 31B, 35D, 91F, 92F, 35G, 92G, 15P, 88M, 91M, 35T, 15W, 92Y) for the 19K Armor Crewman 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 H). 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, Soldiers completed a four-week train-up familiarize themselves with the technical aspects of all of the tasks. See Appendix D for details of the training schedule.

TASK SIMULATIONS

Thirteen tasks were identified by TRADOC as relevant to these two MOSs and tested: five relevant to 19D, four relevant to 19K, and three to both (see Table 1.2). One task identified by TRADOC (employing hand grenades) was not tested because it has been demonstrated that skill plays a greater role than physiological demand, and that task performance is not always repeatable (35). Of the 13 tasks, four of the tasks (prepare a fighting position, both casualty evacuations, and stow ammo) were divided into multiple parts for the purpose of understanding the unique demands of different aspects of the task. For Task 3 preparing the fighting position, the two aspects were sandbag filling and sandbag carrying segments. For Task 4b Bradley Fighting Vehicle (BFV) casualty evacuation, Soldiers were tested both as a team and individuals. For Task 20 Abrams casualty evacuation, Soldiers were tested as part of a team from both the outside and inside position, as well as solo from the outside. Finally, for Task 18 stow ammo, Soldiers were measured loading rounds from the ground to the hull (outside) and from the hatch into the ammo rack (inside). Additionally, Task 19 load the main gun was completed once in the Abrams and once in a custom built simulator. This is due to the difficulty getting an accurate measure of time to complete the task in the Abrams. The inert rounds needed to be unloaded from the breech after each round, requiring the clock to be stopped.

During each task Soldiers wore the designated uniform (with associated load) as defined by the SMEs from the Armor School. The full breakdown of the each load is

illustrated in Appendix B. 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 63.1-77.5 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 size. The task specific uniform can vary between 42.5-57.1 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 Armor 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 G and H, respectively.

1. Foot March (19D & 19K; Figure 1.1)

Conduct a Tactical Movement

Soldiers completed a 12-mile foot movement, wearing the 24-hour sustainment load (approximately 102 lb of equipment). Three mandatory rest stations were placed on the course at miles 3, 6 and 9. Soldiers were required to rest for approximately 10 minutes at the first and third station and for 30 minutes at the midpoint station. This will represented a simulation of a mission execution. Soldiers were allowed to take additional breaks as needed, and were permitted to stay at each official rest stop longer if needed. Soldiers were instrumented with a heart rate monitor and a timing chip (SPORTident Model SIAC1, Arnstadt, Germany). Heart rate, rate of perceived exertion (RPE) and timing splits were collected at each rest stop as well as at the start and finish line. For simplicity, only the finish line data are presented in this document.

Army Standard: Successful completion of the task

2. Employ Hand Grenades (19D & 19K; 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 (19D & 19K; 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 26 times 55 to 60% full (30-40 lb of sand).

Army Standard: Fill 26 sandbags in 52 minutes

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 minutes. 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 minutes

4a. Casualty Drag (19D & 19K; Figure 1.3)

Drag a Casualty to Immediate Safety (Dismounted)

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-minute

4b. BFV Casualty Evacuation (19D; 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 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 it was tested as a member of a two person team with the bag weighted at 207 lb. Learning from the testing during the development of the 12B test battery (11), Soldiers also performed the task once solo, with the bag weighted at 103.5 lb.

Army Standard: Casualty removed from vehicle in 2 minutes

5. 25mm Barrel Install (19D; Figure 1.5)

Lift, Carry, and Install the Barrel of a 25mm 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 25mm 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 (19D; Figure 1.6)

Remove the Feeder Assembly of a 25mm 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 (19D; Figure 1.7)

Load 25mm HEI-T Ammunition Cans onto the BFV

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 dimension were 36 x 33 x 13 cm. Soldiers carried one or two cans at a time.

Army Standard: Successful completion of the task

8. Load TOW Missile (19D)

Load Tube-Launched, Optically-Tracked, Wire-Guided (TOW) Missile Launcher on the BFV

While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers loaded and unloaded two TOW 2B Aero Missiles (65 lb) into the BFV Mounted TOW Weapon System.

Army Standard: Successful completion of the task

17. Mount .50 Caliber Machine Gun (19K)

Mount M2 .50 Caliber Machine Gun on the Abrams Tank

While wearing a task specific uniform weighing approximately 49 lb, Soldiers lifted the M2 .50 caliber machine gun (56 lb) from the ground to the gun mount on an Abrams Tank.

Army Standard: Successful completion of the task

18. Stow Ammo (19K)

Stow Ammunition on Abrams Tank

While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers completed two subtasks in order to test the individual demands of stowing ammunition on the Abrams tank. These subtasks are outlined below. Soldiers had rest period of at least 5 minutes between completion of the subtasks.

Part A: Outside (Hull)

Soldiers moved 36 rounds (weighing no more than 55 lb each) from an ammunition point to the tables simulating the deck of a tank. The ammunition point was placed 5 m from the simulated deck of the tank.

Part B: Inside (Ready Rack)

Soldiers moved 36 rounds from the turret of the tank into the ammunition rack inside the Abrams. Soldiers were handed a round from the turret and were required to lower it into the tank to place it into the rack.

Army Standard: Moved 36 rounds in 20 minutes for each phase

19. Load the Main Gun (19K)

Load the 120mm Main Gun on an Abrams Tank

While wearing a task specific uniform (approximately 49 lb), Soldiers will loaded five 120mm MPAT rounds into the breach of the Abrams tank main gun as quickly as possible. Soldiers also performed this task on a simulator outside the tank to determine how quickly the rounds can be loaded when there was no requirement to remove the round from the breech between loadings.

Army Standard: Successful completion of the task

20. Abrams Casualty Evacuation (19K)

Remove a Casualty from an Abrams Tank

As part of a three-Soldier team and while wearing a fighting load minus the weapon (approximately 71 lb), Soldiers removed a simulated casualty (approximately 225 lb, prorated at 75 lb/Soldier) from the commander's seat of an Abrams tank. The same haul bag used in Task 4b was used in this task. When the task was performed as a team of three Soldiers, two Soldiers were outside of the hatch and one was inside of the tank. Soldiers performed this task three times: once as part of a team on the outside of the hatch, once as a member of a team from the inside of the hatch, and once solo from the outside with the bag weighted at 75 lb.

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.

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, and 18), and tasks primarily driven by strength (Tasks 4a, 4b, 5, 6, 8, 17, 19, and 20) graded on the CR-10 (i.e. 1-10) scale. Tasks with an approximate duration of greater than 5 minutes were deemed aerobic tasks, while the remainder were identified as strength tasks.

Metabolic data were also collected for the aerobic tasks using an Oxycon Mobile Metabolic Unit (CareFusion, San Diego, CA) for Tasks 3, 7, and 18 (outside phase only). Data were output using 1-minute 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 oxygen uptake (VO_2) in absolute units (L/min), average VO_2 relative to body mass (ml/kg/min), and percent of estimated VO_2 max. VO_2max was estimated using the following equation (22):

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

Absolute total O_2 consumption (L, product of average VO_2 and time) 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. Each MOS was analyzed independently.

For each task and outcome variable, mean and standard deviations were calculated separately for each 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 to ensure that the data corresponded to acceptable performance. 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.

STUDY 1: RESULTS

SOLDIER VOLUNTEER CHARACTERISTICS

Characteristics of the Soldiers tested are summarized in Table 1.3. For both cohorts males were taller and heavier than the females ($p<0.01$). Overall APFT scores were similar by sex for both cohorts ($p \geq 0.34$), but the males in both cohorts had higher push-up and faster 2-mile run raw scores ($p<0.01$). In the 19D cohort, males had a higher estimated VO_2max ($p=0.02$) than females, however there was no difference in the 19K cohort ($p=0.16$)

The data from the training and deployment questionnaire are shown in Table 1.4. Training data indicates that the most commonly performed 19D aerobic task in training and deployed was the foot march. The most common strength task in both settings was the casualty drag. Of the 19K tasks, the stow ammo task was the most commonly performed aerobic task in training, though none of the 19Ks had done this in a deployed setting. The most common aerobic task performed while deployed was the foot march. Of the strength tasks, the mounting the .50 caliber gun was most commonly performed in training, but again this task was never performed in a deployed setting. The strength task reported by the 19K to be performed the most while deployed was the casualty drag. Notably, none of the six 19K who had been deployed had performed any of the 4

19K specific tasks (stow ammo, mount .50 caliber gun, load the main gun, or Abrams casualty evacuation) during their deployment.

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 filling phase of fighting position.

Of those who attempted the 19D tasks, four of the tasks were not completed to standard by all. While there was no formal time standard, four female Soldiers in the 19D cohort were unable to complete the foot march. In addition,three females Soldiers were unable to complete the casualty drag, four female Soldiers were unable to lift the casualty from the BFV, and one female Soldier was unable to load the TOW missile.

Three of the tasks performed by the 19K cohort were completed to standard. One female Soldier was unable to complete the inside phase of the stow ammo, six female Soldiers were unable to complete the casualty drag, and four female Soldiers were unable to load the main gun in under 35 seconds.

PHYSICAL DEMANDS OF 19D TASKS

Physiological data were calculated only for individuals who completed the task to standard. Times to task completion for the aerobic and strength tasks are shown in Figure 1.8 (TOP LEFT). The foot march was the aerobic tasks that took the longest time to complete. Of the aerobic tasks, the foot march was perceived (Figure 1.9, TOP LEFT) to have the greatest exertion. The greatest end-task heart rates (Figure 1.10, TOP LEFT) were observed during the carry phase of the fighting position and the ammo can carry. When measuring average heart rate during aerobic tasks (Figure 1.10 BOTTOM LEFT), the carry phase of the fighting position ranked highest. The ammo can carry ranked highest in VO_2 in absolute terms (Figure 1.11, TOP LEFT), but when normalized to body mass (Figure 1.11, MIDDLE LEFT) or estimated VO_2max (Figure 1.11, BOTTOM LEFT), the carry phase of the fighting position matched the ammo can carry in the top rank. Likewise, total oxygen consumption (a surrogate for total energy expenditure) was highest in the ammo can carry in absolute terms (Figure 1.12, TOP LEFT), but matched by both phases of the fighting position when normalized to body mass (Figure 1.12, BOTTOM LEFT). The heaviest loads of the 19D tasks were the 270-lb dragged for the casualty drag and 103.5 prorated lb lifted for the BFV casualty evacuation. The 25mm barrel install took the longest of the strength tasks (Figure 1.8, BOTTOM LEFT). The casualty drag and casualty evacuation were perceived to require the greatest exertion of the strength tasks (Figure 1.9, BOTTOM LEFT). A summary of 19D tasks deemed most difficult for each measure, by nature of being in the top rank, is provided in Table 1.6.

Females took longer to complete all 19D tasks except for the team casualty evacuation and the feeder assembly. All tasks except for the feeder assembly had

higher ratings of perceived exertion for the females than the males. There was no difference in mean or end heart rate by sex. Of the tasks where metabolic data were collected, females had lower absolute VO_2 for both phases of the fighting position and for the ammo can carry. When normalized to body mass, females still had a lower relative VO_2 for the carry phase of the fighting position and the ammo can carry; however, these differences disappeared when normalized to estimated VO_2max. Absolute total O_2 consumption was similar between males and females, but females had greater O_2 consumption relative to body mass for the carry phase of the fighting position than the males. A summary of sex differences for the 19D cohort is provided in Table 1.7

PHYSICAL DEMANDS OF 19K TASKS

Of the 19K tasks, the foot march was the aerobic tasks that took the longest (Figure 1.8, TOP RIGHT). Of the aerobic tasks, the foot march and carry phase of the fighting position were perceived to have the greatest exertion (Figure 1.9, TOP RIGHT). The greatest end-task (Figure 1.10, TOP RIGHT) and average (Figure 1.10 BOTTOM RIGHT) heart rates were observed during the carry phase of the fighting position and outside (hull) phase of stow ammo. No matter how VO_2 was normalized (Figure 1.11 RIGHT), the carry phase of the fighting position matched the outside (hull) phase of stow ammo in the top rank. Total oxygen consumption was highest in the outside (hull) phase of stow ammo task whether measured in absolute terms or normalized to body mass (Figure 1.12 RIGHT). The heaviest loads of the 19K tasks were the 270-lb dragged for the casualty drag and 75 prorated lb lifted for the Abrams casualty evacuation. Mounting the .50 caliber gun took the longest of the strength tasks (Figure 1.8, BOTTOM LEFT). Like with the 19D, the casualty drag was perceived to require the greatest exertion of the strength tasks (Figure 1.9, BOTTOM LEFT). A summary of 19K tasks deemed most difficult for each measure, by nature of being in the top rank, is provided in Table 1.8.

In the 19K cohort, females took longer than the males to perform five tasks: the foot march, both phases of the stow ammo, the casualty drag, and mounting the .50 cal. Females perceived the casualty drag, mounting the .50 cal, stow ammo in a tank, and the solo casualty evacuation to be more difficult than the males. End heart rate was higher for the females for both phases of the stow ammo task, but no difference in mean heart rate was observed. For the three tasks where metabolic measurements were recorded, females had a lower absolute VO_2 on all 3 tasks, lower VO_2 relative to body mass for both phases of the fighting position, and lower VO_2 relative to estimated VO_2max for only the carry phase of the fighting position. Absolute, but not body-mass normalized, total O_2 consumption was lower for the fill phase of the fighting position; while body-mass normalized, but not absolute, total O2 consumption was greater in the females for the ground to hull phase of the stow ammo. A summary of sex differences for the 19D cohort is provided in Table 1.9

STUDY 1: DISCUSSION

This descriptive study identified the frequency and physiological demands of most physically demanding tasks performed by Armor Soldiers. From these data, the foot march and the casualty drag were identified as the most commonly performed 19D tasks. Of the aerobic tasks, the foot march rated hardest for task duration and RPE. The carry phase of the fighting position and the ammo can carry were both in the highest rank for end task heart rate, but the fighting position had a higher average heart rate. For the metabolic measures, the ammo can carry had the highest demand on an absolute level, but when normalized to body mass or estimated VO_2max, the ammo can carry was no different from either phase of the fighting position. Of the strength tasks, the casualty drag and the BFV casualty evacuation had the heaviest loads, 25mm barrel install took the longest, and the casualty drag had the highest RPE.

For the 19K, stow ammo, foot march, casualty drag, and mounting the .50 caliber gun were the most frequently performed tasks. While the stow ammo task was listed as being frequently performed in training, none of the Soldiers who had been deployed reported doing it during their deployment. Of the aerobic tasks, the foot march rated hardest for task duration and RPE. The carry phase of the fighting position and the ammo can carry were both in the highest rank for end task heart rate, average heart rate, and VO_2; however, a greater total O_2 cost was required to complete the stow ammo task. Of the strength tasks, the casualty drag and the Abrams casualty evacuation had the heaviest loads, mounting the .50 caliber gun took the longest, and the casualty drag had the highest RPE.

PHYSICAL DEMANDS OF TASKS

The carry phase of the fighting position and the ammo can carry are the most demanding repetitive lift and carry tasks for the 19D tasks; while the carry phase of the fighting position and the stow ammo task are the most demanding repetitive lift and carry tasks for the 19K. For either MOSs pairing, there is no statistical difference among the VO_2 measures for these two tasks when normalized to body weight. There are several possible rationales for this. One possibility is that the physical demands of performing each task to Army standards are very similar. Given that all three tasks require similar movements with similar weights (carry 35-55 lb, 5-15 m, 26-36 times), this is not an unreasonable explanation. It is also possible Soldiers are working close to their VO_2 max, and there is a ceiling effect to their VO_2. This seems unlikely given their predicted VO_2 max (see Table 1.3). It is also possible that Soldiers are self-selecting a pace they know they can maintain. At least during long-duration load carriage, it has been shown that Soldiers will self-select a pace of ~45% of their VO_2 max independent of load carried (10). While we observed Soldiers at closer to ~60% of VO_2max, this difference in pace selection may be due to the much shorter nature of the lift and carry tasks.

A number of the tasks required teamwork in groups of two or more participants. These include the strength tasks of the two casualty evacuations and 25mm barrel install. 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 five tasks which were split into multiple parts, four were found to have similar physiological demands on both parts. Three of the tasks were split for technical reasons. For the both of casualty evacuations time to complete and RPE responses were similar whether Soldiers were performing the task solo or as part of a team. Likewise, time and RPE were similar for the load the main gun whether performed in the tank or with our simulator. This supports the concept that our modifications accurately mimicked the physical demands of the original tasks. The remaining two tasks were split in order to better understand two distinct phases of the task. We observed similar heart rate responses for both phases of the stow ammo. Due to technical constraints, we were unable to make any metabolic measurements in the tank; however, given the similar HR responses and similarities in the tasks, it is reasonable to assume the VO_2 values were similar. In contrast, there were differences in the two phases of the fighting position. Heart rate and VO_2 were lower for the fill phase of the fighting position than the carry phase. This is not unexpected due to the large differences in the requirements of the two phases of this task.

SEX DIFFERENCES

While females may have been slower or perceived many of the tasks to be more difficult than males, it is important to note that the majority of the females tested were able to perform the tasks to standard with only four weeks of training on the tasks. The task with the greatest number of females unable to complete the task to standard was the casualty drag. Still, 21 of the 30 females tested (70%) were able to complete the task in a time acceptable to TRADOC. Thus, there could be a large proportion of females who would be successful in these MOSs if they were open to females

Many of the tasks the females struggled with were very strength intensive. For both MOSs, females took longer for the casualty drag. In addition, they perceived the casualty drag and casualty evacuation as being more challenging than the males. Females were less likely to complete these tasks successfully than males. These two tasks involve the heaviest weights of all the strength tasks. This is likely, in part, due to the fact that females generally have less lower-limb muscle mass than males (32). If females are going to be permitted to join these MOSs, it is likely that some type maximal leg strength test will be necessary in order to ensure that Soldiers have the necessary strength to perform 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 (19D: fighting position and ammo can carry; 19K: fighting position and stow ammo), and extended duration load carriage (19D & 19K: foot march). The strength tasks can be broken into heavy lift (19D: BFV casualty evacuation, 25mm barrel install, feeder assembly, and load TOW missile; 19D: Abrams casualty evacuation, mount .50 caliber gun and load the main gun) and heavy drag (19D & 19K: casualty drag). All of the physical demands required for these job tasks should be represented in a set of tasks asks identified for simulations. Additionally, these tasks should:

- Test individuals, not teams
- Allow for a range of scores to show differences between people (cannot be go/no-go)
- 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

Both MOSs had only one task that could be considered a load carriage task: the foot march. This task took much longer than any other tasks (hours instead of minutes), and was rated as having the highest RPE. Thus, the road march task should be included in future studies.

All three of the repetitive lift and carry tasks for the 19D were in the most physically demanding group for at least one of the measures (oxygen uptake, total O_2 cost, heart rate, RPE; Figures 1.9-1.12). The carry phase of the fighting position was in the top rank of each measure. It had both high end-task and mean HR, and high metabolic measures when normalized to body mass. On the other hand, the ammo can carry rated higher on the absolute and normalized metabolic measures, but it had a lower mean heart rate than the carry phase of the fighting position. Since both task are not highly skilled, have among the highest physical demands, and require minimal equipment, the ammo can carry and fighting position are both likely candidates for use in future studies. Both the carry phase of the fighting position and the stow ammo have highest physical demands of the 19K repetitive lift and carry tasks. While the inside phase of the stow ammo task may have high metabolic demands they are likely similar to the outside phase. The technical difficulties of simulating the inside phase make it difficult to consider for future testing. Of the two remaining tasks (outside phase of the stow ammo and carry phase of the fighting position), sandbags are easier acquire than MPAT rounds; however, MPAT rounds are heavier (55 vs 35 lb) and more of them are required to be moved (36 vs 26). In addition, the MPAT round movement requires not only a carry, but a lift of ~64 inches to reach the Soldier receiving the round on the deck

of a tank. For these reasons, the stow ammo task seems like the more appropriate 19K task for future simulation.

Among the strength tasks, the both casualty evacuations had the greatest weight lifted of all the tasks relevant to their respective MOS. For the 19D, the BFV evacuation has a prorated weight of 103.5 lb, and for the 19K, the Abrams evacuation has a prorated weight of 75 lb. In this study, we were able to simulate the task as an individual task. In addition, this task is commonly performed both in training and deployed settings, and is important to the health and safety of the Soldiers. Thus, the casualty evacuations may best heavy lift tasks for future task simulations. The 19K task of Load the main gun requires the ability to lift quickly and accurately place rounds weighing approximately 55 lb into the breach of a tank. This action requires a degree of precision and control of the weight which is not reflected in the casualty evacuation. For this reason, the loading the main gun task should also be considered for future simulations.

For both MOS, the casualty drag should be simulated due to its unique motion, high physical demands (weight, 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., haul bag used for casualty extraction). Tasks were completed on 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 subject matter experts. It is possible that in a real situation, there may be variations on the task which may increase or decrease the individual demands, such as material on which the casualty is dragged, distance of carry (ammo cans, sandbags, MPAT rounds), 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 19D Cavalry Scouts and 19K M1 Armor Crewmen. Among the most physically demanding tasks for the 19D are the carry phase of the fighting position, ammo can carry, BFV casualty evacuation, casualty drag, and the foot march. For the 19K, the most demanding tasks were the stow ammo on an

Abrams, Abrams casualty evacuation, casualty drag, and foot march. Load the main gun task may also be considered a task with physical demands not captured in the remaining 19K tasks.

STUDY 1: RECOMMENDATIONS

1. SMEs should be consulted to determine whether sandbags or ammo cans are the preferable task to use for simulations in the prediction model development.

2. SMEs should approve of the alteration of the casualty evacuations into solo tasks, and the use of simulations for the stow ammo and loading the main gun tasks.

3. Reliability of the tasks, particularly those using custom designed simulators, needs to be established.

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 Armor Tasks and Measurements from Ft. Stewart

Task #	Performed by 19D	Performed by 19K	Occupational-Related Tasks	Measures
Aerobic Tasks				
1	X	X	Conduct a 12-Mile Foot March	Time, RPE 6-20, HR
3	X	X	Prepare a Fighting Position (Fill and Emplace Sandbags)	Time, RPE 6-20, HR, VO_2
7	X		Load 25mm HEI-T Ammunition Cans onto the Bradley Fighting Vehicle	Time, RPE 6-20, HR, VO_2
18		X	Stow Ammunition on Abrams Tank	Time, RPE 6-20, HR, VO_2 (VO_2 only for outside)
Strength Tasks				
4a	X	X	Drag a Casualty to Immediate Safety (Dismounted)	Time, RPE CR-10
4b	X		Remove a Casualty from a Vehicle (Mounted)	Time, RPE CR-10
5	X		Lift, Carry, and Install the Barrel of a 25mm gun on the BFV	Time, RPE CR-10
6	X		Remove the Feeder Assembly of a 25mm Gun on the BFV	Time, RPE CR-10
8	X		Load TOW Missile Launcher on BFV	Time, RPE CR-10
17		X	Mount M2 .50 Caliber Machine Gun on Abrams Tank	Time, RPE CR-10
19		X	Load the 120mm Main Gun on an Abrams Tank	Time, RPE CR-10
20		X	Remove a Casualty from an Abrams Tank	Time, RPE CR-10

Table 1.3. Soldier Characteristics: Study 1

19D: Cavalry Scout	**Males (n=23)**	**Females (n=15)**	**p-value**
Age (years)	21.5 ± 2.2	23.7 ± 3.8	0.03
Height (cm)	179.4 ± 7.8	165.7 ± 7.0	<0.01
Mass (kg)	84.6 ± 11.9	67.6 ± 9.0	<0.01
Time in Military (years)	2.1 ± 1.7	2.6 ± 1.7	0.44
Time in MOS (years)	2.0 ± 1.6	2.5 ± 1.6	0.36
Number Deployed (%)	9 (39%)	4 (27%)	–
Time Deployed (years) *for only those who have deployed*	0.9 ± 0.7	0.6 ± 0.3	0.41
Army Physical Fitness Test score (points)	252.5 ± 27.0	251.6 ± 34.6	0.93
Push-ups (# / 2 min)	69.5 ± 11.3	44.8 ± 13.7	<0.01
Sit-ups (# / 2 min)	68.4 ± 11.5	68.3 ± 12.7	0.97
Two-Mile Run Time (min)	14.5 ± 1.2	17.6 ± 1.6	<0.01
Predicted VO_2max (ml/kg/min)	50.7 ± 4.6	46.4 ± 5.9	0.02
19K: Armor Crewman	**Males (n=23)**	**Females (n=15)**	**p-value**
Age (years)	22.4 ± 3.1	24.8 ± 3.4	0.03
Height (cm)	179.7 ± 6.0	164.5 ± 6.8	<0.01
Mass (kg)	81.3 ± 10.5	66.7 ± 9.8	<0.01
Time in Military (years)	1.8 ± 1.2	2.3 ± 1.5	0.28
Time in MOS (years)	1.8 ± 1.2	1.9 ± 1.5	0.75
Number Deployed (%)	6 (26%)	5 (33%)	–
Time Deployed (years) *for only those who have deployed*	0.8 ± 0.0	0.8 ± 0.3	0.88
Army Physical Fitness Test score (points)	255.9 ± 30.5	264.7 ± 19.6	0.34
Push-ups (# / 2 min)	68.4 ± 13.1	48.5 ± 9.2	<0.01
Sit-ups (# / 2 min)	68.3 ± 9.6	67.5 ± 10.3	0.82
Two-Mile Run Time (min)	14.5 ± 1.0	16.8 ± 1.6	<0.01
Predicted VO_2max (ml/kg/min)	51.2 ± 4.4	48.7 ± 5.8	0.16

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

19D: Cavalry Scout		Males		Females	
		In Training n=23	**Deployed n=9**	**In Training n=23**	**Deployed n=9**
Aerobic Tasks	**1: Foot March**	22.5 ± 17.7 (4-61)	24.2 ± 66.7 (0-300)	10.6 ± 8.1 (0-30)	0.2 ± 0.6 (0-2)
	3: Fighting Position	8.0 ± 9.2 (1-40)	4.5 ± 8.0 (0-20)	1.1 ± 1.8 (0-5)	0.0 —
	7: Ammo Can Carry	7.9 ± 12.3 (0-60)	0.1 ± 0.5 (0-2)	1.2 ± 1.9 (0-5)	0.0 —
Strength Tasks	**4a: Casualty Drag**	8.8 ± 7.4 (2-30)	0.6 ± 1.3 (0-5)	12.1 ± 18.0 (0-50)	0.2 ± 0.6 (0-2)
	4b: BFV Cas Evac	6.5 ± 4.0 (1-15)	0.5 ± 1.2 (0-5)	3.6 ± 4.7 (0-15)	0.1 ± 0.5 (0-2)
	5: 25mm Barrel Install	11.4 ± 11.6 (0-45)	0.1 ± 0.5 (0-2)	1.1 ± 2.0 (0-5)	0.0 —
	6: Feeder Assembly	12.0 ± 13.2 (0-60)	0.1 ± 0.5 (0-2)	1.9 ± 3.5 (0-11)	0.0 —
	8: Load TOW Missile	5.8 ± 4.5 (0-15)	0.1 ± 0.3 (0-1)	2.0 ± 3.4 (0-10)	0.0 —
19K: Armor Crewman		**Males**		**Females**	
		In Training n=23	**Deployed n=6**	**In Training n=15**	**Deployed n=5**
Aerobic Tasks	**1: Foot March**	177.7 ± 455.7 (2-2000)	86.5 ± 162.9 (0-650)	8.5 ± 8.2 (0-25)	0.0 —
	3: Fighting Position	66.5 ± 200.6 (0-1000)	5.5 ± 14.1 (0-50)	1.4 ± 2.5 (0-8)	0.0 —
	7: Ammo Can Carry	2.9 ± 6.2 (0-25)	0.1 ± 0.2 (0-1)	0.6 ± 1.5 (0-5)	0.0 —
Strength Tasks	**4a: Casualty Drag**	13.1 ± 27.9 (0-101)	1.7 ± 4.8 (0-20)	2.3 ± 1.8 (0-6)	0.0 —
	17: Mount .50 Caliber	27.5 ± 35.3 (1-101)	6.8 ± 6.1 (0-30)	1.9 ± 3.8 (0-10)	5.1 ± 3.1 (2-10)
	19: Load the Main Gun	40.7 ± 35.8 (4-101)	22.2 ± 21.3 (0-80)	5.4 ± 10.5 (0-30)	17.1 ± 11.5 (0-31)
	20: Abrams Cas Evac [a]	18.7 ± 27.8 (0-101)	0.0 —	3.1 ± 6.3 (0-20)	0.0 —

[a] Data for MOS Specific Tasks while deployed shown only for male Soldiers who retained the MOS (19D, n=9; 19K, n=6)

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 all Tasks

19D: Cavalry Scout		**Number Tested**			**Completion Rate**			**Gender Completion P-Value**
		All	**Male**	**Female**	**All**	**Male**	**Female**	
Aerobic Tasks	**1: Foot March**	38	23	15	**90%**	100%	**73%**	**0.01**
	3: Fighting Position (FILL)	31	16	15	100%	100%	100%	**—**
	3: Fighting Position (CARRY)	37	22	15	100%	100%	100%	**—**
	7: Ammo Can Carry	38	23	15	100%	100%	100%	**—**
Strength Tasks	**4a: Casualty Drag**	38	23	15	**92%**	100%	**80%**	**0.03**
	4b: BFV Cas Evacuation	38	23	15	**90%**	100%	**73%**	**0.01**
	5: 25mm Barrel Install	38	23	15	100%	100%	100%	**—**
	6: Feeder Assembly	38	23	15	100%	100%	100%	**—**
	8: Load TOW Missile	38	23	15	**97%**	100%	**93%**	**0.21**
19K: Armor Crewman		**Number Tested**			**Completion Rate**			**Gender Completion P-Value**
		All	**Male**	**Female**	**All**	**Male**	**Female**	
Aerobic Tasks	**1: Foot March**	38	23	15	100%	100%	100%	**—**
	3: Fighting Position (FILL)	36	21	15	100%	100%	100%	**—**
	3: Fighting Position (CARRY)	36	21	15	100%	100%	100%	**—**
	18: Stow Ammo (HULL)	38	23	15	100%	100%	100%	**—**
	18: Stow Ammo (READY RACK)	37	23	14	**97%**	100%	**93%**	**0.20**
Strength Tasks	**4a: Casualty Drag**	38	23	15	**84%**	100%	**60%**	**<0.01**
	17: Mount .50 Caliber	38	23	15	100%	100%	100%	**—**
	19: Load the Main Gun	38	23	15	**90%**	100%	**73%**	**0.01**
	20: Abrams Cas Evacuation	38	23	15	100%	100%	100%	**—**

Bolding indicates <100% successful completion rate

Table 1.6. Summary of Physical Demands of Tasks of 19D

		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: Fighting Position (FILL) *Repeated Lift & Carry*	*35*						† ***(relative)***
	3: Fighting Position (CARRY) *Repeated Lift & Carry*	*35*			†	†	† ***(relative & predicted VO2max)***	† ***(relative)***
	7: Ammo Can Carry *Repeated Lift & Carry*	*45*			†		† ***(absolute, relative, & predicted VO2max)***	† ***(absolute & relative)***
Strength Tasks	***4a: Casualty Drag*** *Heavy Drag*	*270*		†				
	4b: BFV Cas Evac (TEAM) *Heavy Lift*	*103*		†				
	4b: BFV Cas Evac (SOLO) *Heavy Lift*	*103*						
	5: 25mm Barrel Install *Heavy Lift*	*53.5*	†					
	6: Feeder Assembly *Heavy Lift*	*59*						
	8: Load TOW Missile *Heavy Lift*	*71*						

[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 (19D)

		Time	RPE	End HR	Mean HR	VO_2	Total O_2
Aerobic Tasks	**1: Foot March**	F>M	F>M	F=M			
	3: Fighting Position (FILL)	F>M	F>M	F=M	F=M	ABS: F<M REL: F=M %MAX: F=M	ABS: F=M REL: F=M
	3: Fighting Position (CARRY)	F>M	F>M	F=M	F=M	ABS: F<M REL: F<M %MAX: F=M	ABS: F=M REL: F>M
	7: Ammo Can Carry	F>M	F>M	F=M	F=M	ABS: F<M REL: F<M %MAX: F=M	ABS: F=M REL: F=M
Strength Tasks	**4a: Casualty Drag**	F>M	F>M				
	4b: BFV Cas Evac (TEAM)	F=M	F>M				
	4b: BFV Cas Evac (SOLO)	F>M	F>M				
	5: 25mm Barrel Install	F>M	F>M				
	6: Feeder Assembly	F=M	F=M				
	8: Load TOW Missile	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

Table 1.8. Summary of Physical Demands of Tasks of 19K

			Task in top rank of physical demand by:					
		Prorated Load Carried[a] (lb)	**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: Fighting Position (FILL) *Repeated Lift & Carry*	*35*						
	***3:* Fighting Position (CARRY)** *Repeated Lift & Carry*	*35*		*†*	*†*	*†*	*†*	
	18: Stow Ammo (OUTSIDE) Repeated Lift & Carry	55			†	†	†	†
	18: Stow Ammo (INSIDE) Repeated Lift & Carry	55						
Strength Tasks	***4a: Casualty Drag*** *Heavy Drag*	*270*		*†*				
	17: Mount .50 Caliber Max Heavy Lift	56	†					
	19: Load the Main Gun Rapid Heavy Lift	55						
	20: Abrams Cas Evac (TEAM, TOP) Max Heavy Lift	75						
	20: Abrams Cas Evac (TEAM, BOTTOM) Max Heavy Lift	75						
	20: Abrams Cas Evac (SOLO, TOP) Max Heavy Lift	75						

[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 1.9. Tasks with Sex Differences (19K)

		Time	RPE	End HR	Mean HR	VO_2	Total O_2
Aerobic Tasks	**1: Foot March**	F>M	F=M	F=M			
	3: Fighting Position (FILL)	F=M	F=M	F=M	F=M	ABS: F<M REL: F<M %MAX: F=M	ABS: F<M REL: F=M
	3: Fighting Position (CARRY)	F=M	F=M	F=M	F=M	ABS: F<M REL: F<M %MAX: F<M	ABS: F<M REL: F=M
	18: Stow Ammo (HULL)	F>M	F=M	F>M	F=M	ABS: F<M REL: F=M %MAX: F=M	ABS: F=M REL: F>M
	18: Stow Ammo (READY RACK)	F>M	F=M	F>M			
Strength Tasks	**4a: Casualty Drag**	F>M	F>M				
	17: Mount .50 Caliber	F>M	F>M				
	19: Load the Main Gun (TANK)	F=M	F>M				
	19: Load the Main Gun (SIMULATION)	F=M	F=M				
	20: Abrams Cas Evac (TEAM, TOP)	F=M	F=M				
	20: Abrams Cas Evac (TEAM, BOTTOM)	F=M	F=M				
	20: Abrams Cas Evac (SOLO, TOP)	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. Images of Soldiers Conducting a Foot March (Task 1)

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

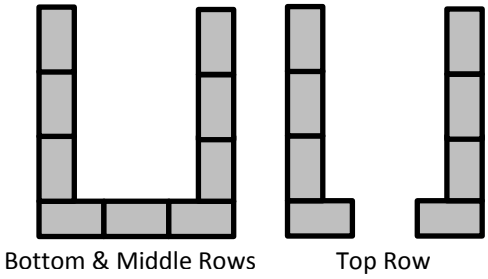


Figure 1.3. Image of Soldier Dragging the Simulated Casualty (Task 4a)

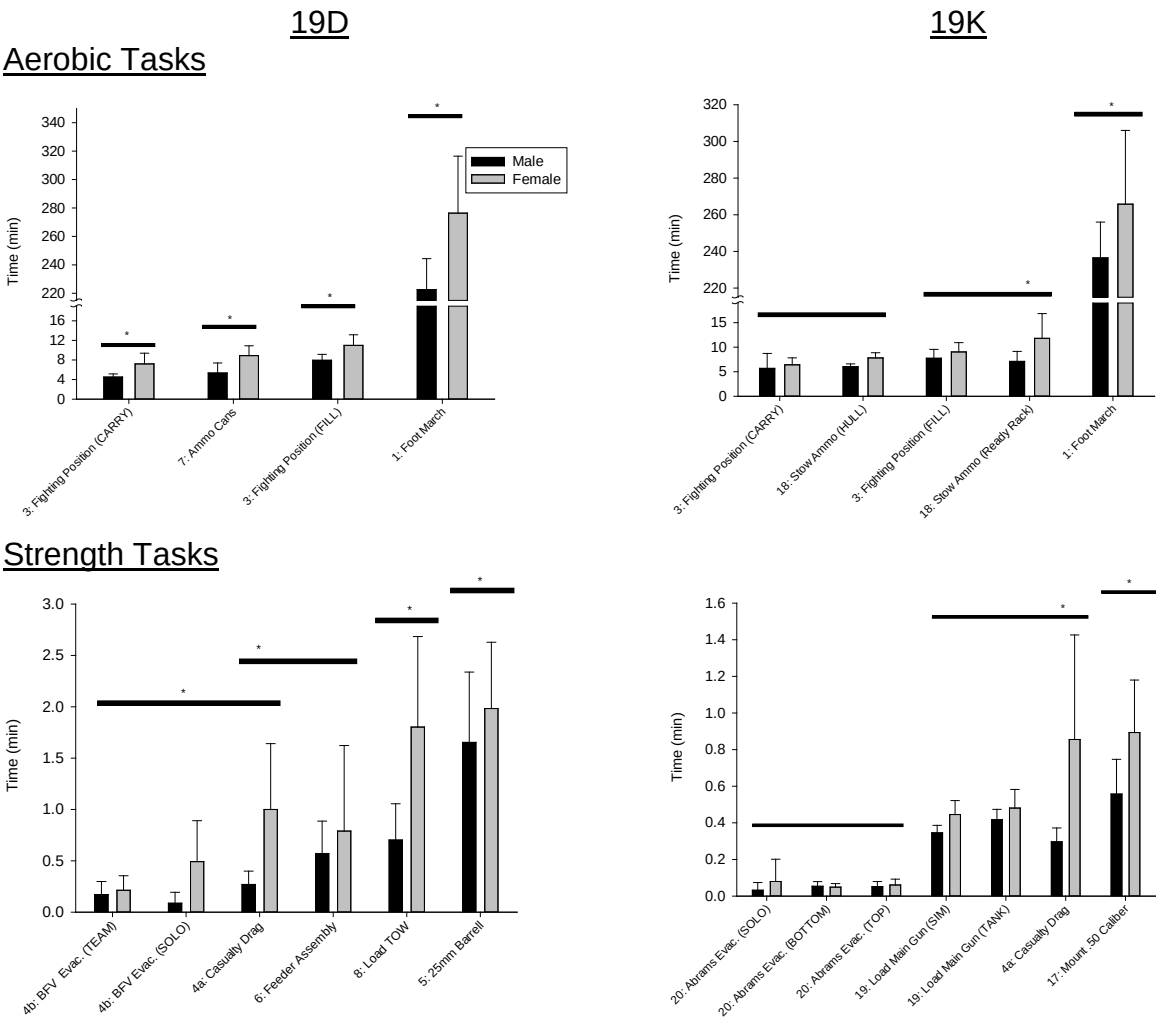
Figure 1.4. Image of Soldier Evacuating the Simulated Casualty from a BFV (Task 4b)

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

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

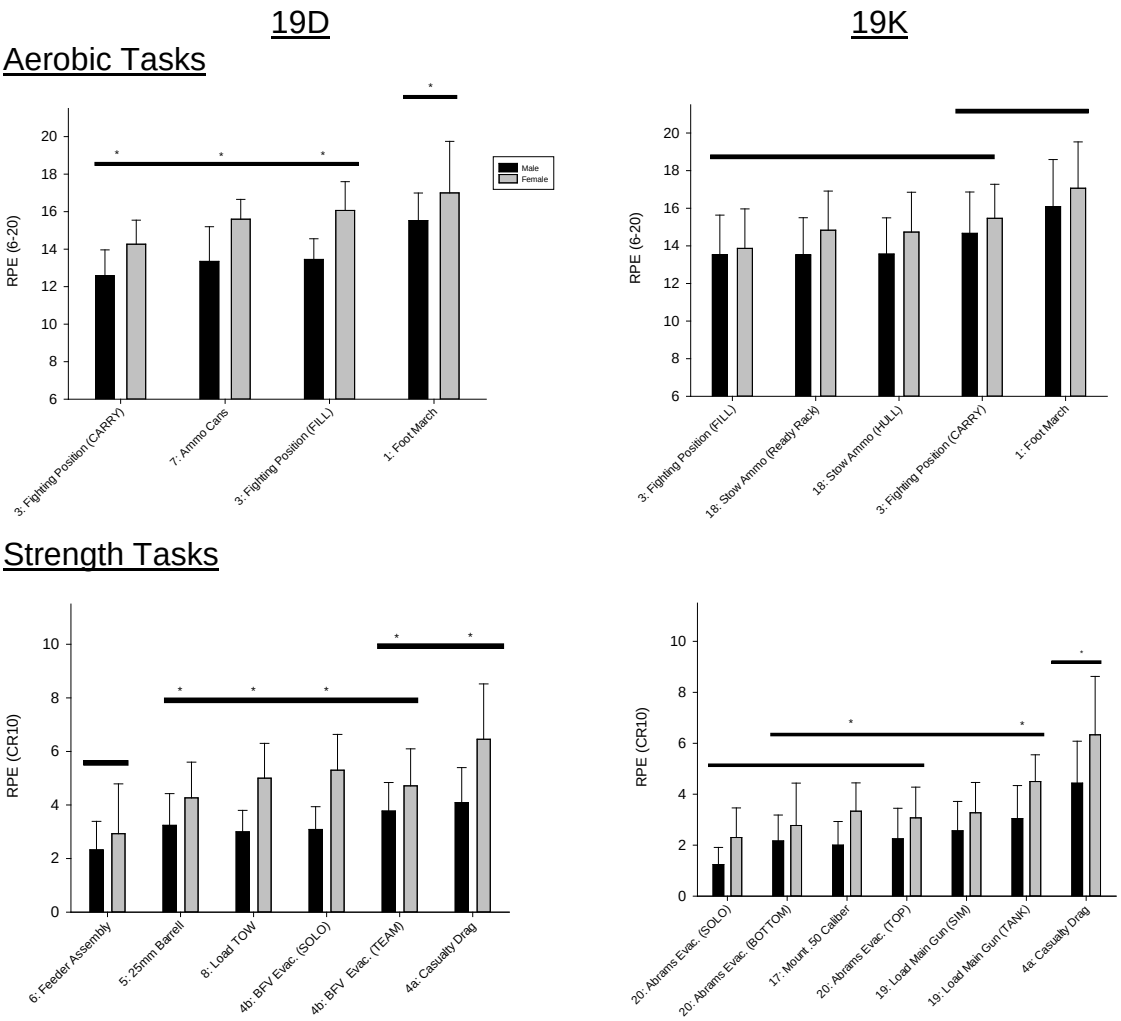
Figure 1.7. Images of Soldier Loading 25mm HEI-T Ammunition Cans (Task 7)

Figure 1.8. Time to Completion for Aerobic (TOP) and Strength (BOTTOM) Tasks



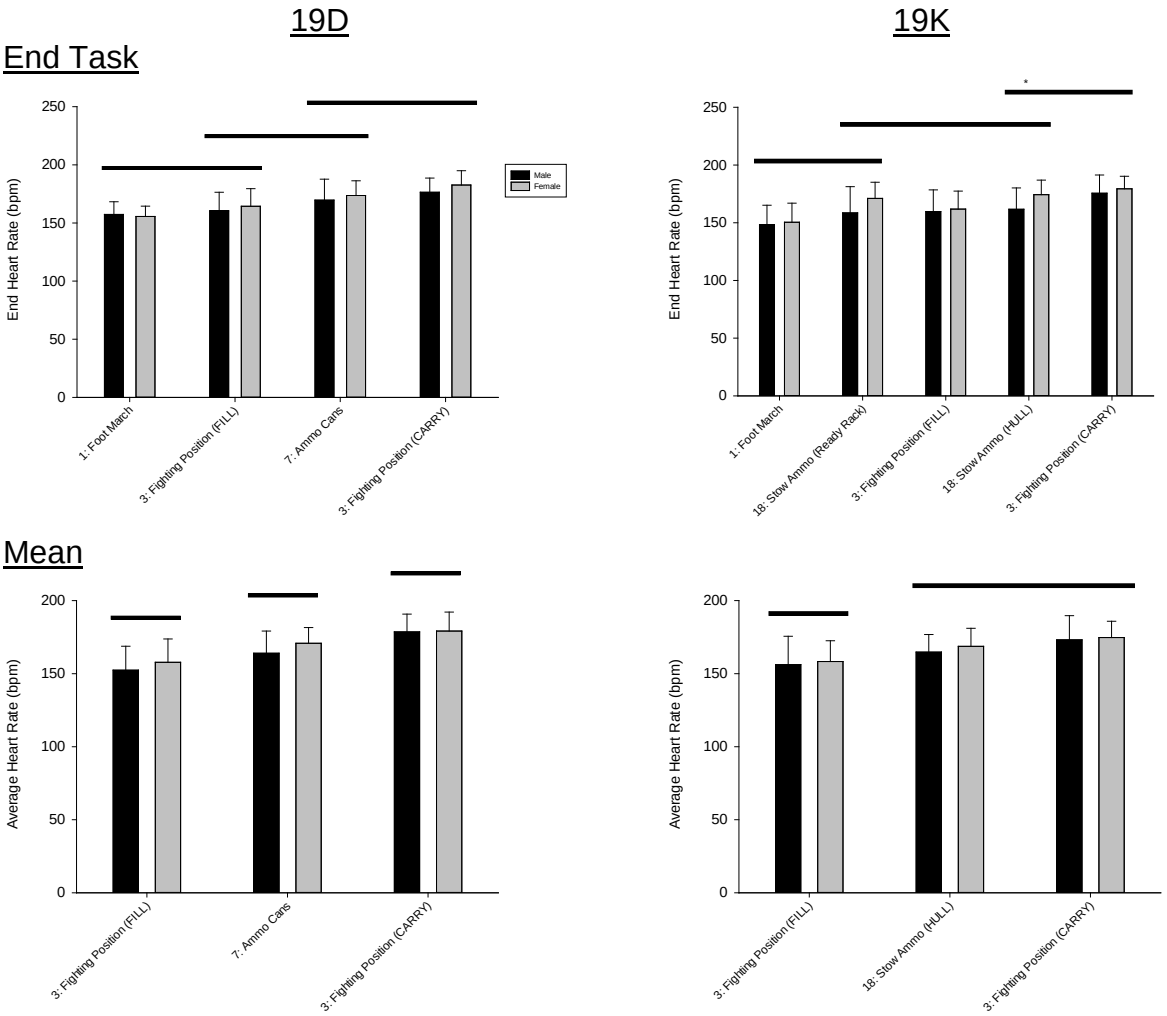
Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.

Figure 1.9. Ratings of Perceived Exertion for Aerobic (TOP) and Strength (BOTTOM) Tasks



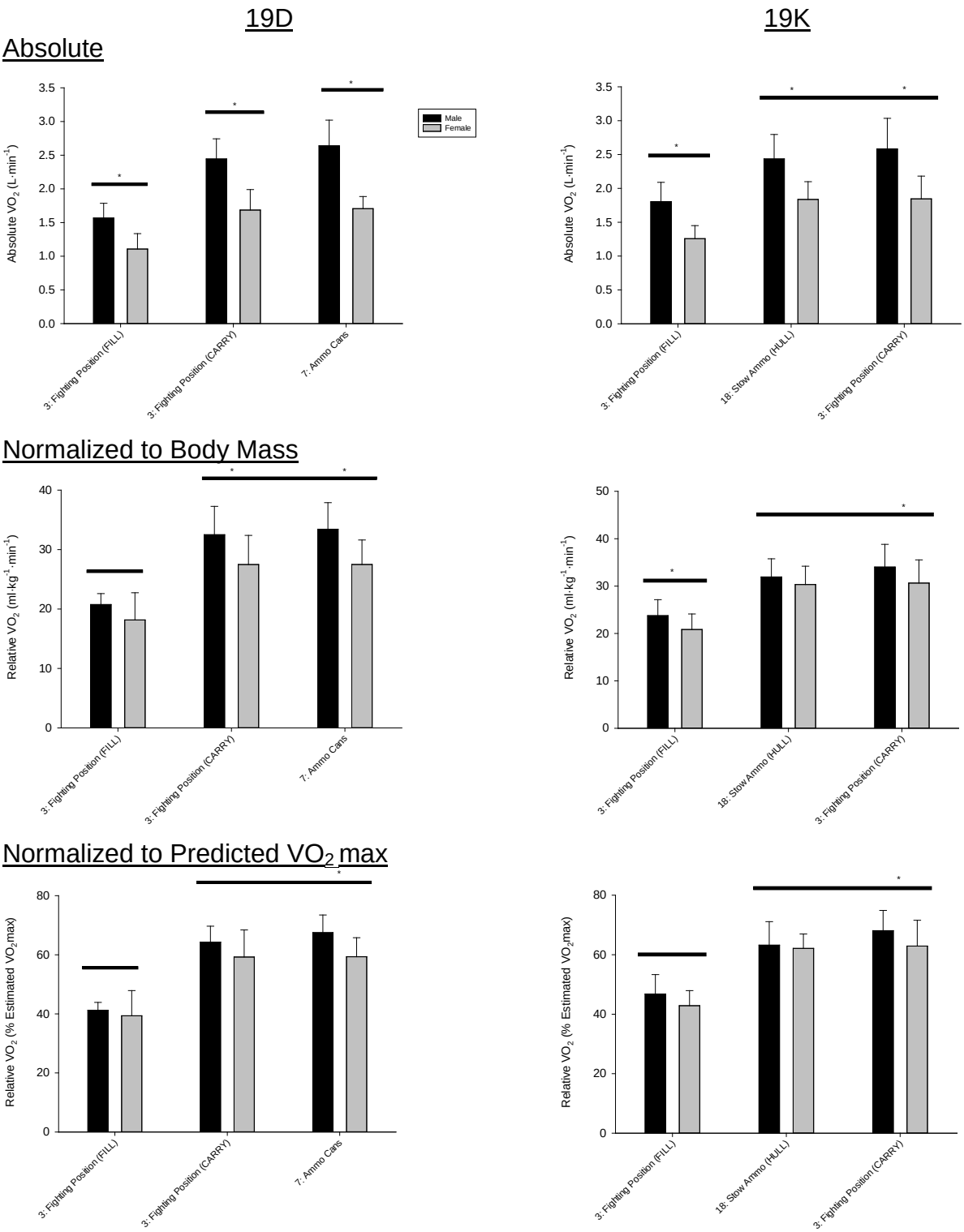
Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.

Figure 1.10. End Task (TOP) and Mean (BOTTOM) Heart Rates for Aerobic Tasks



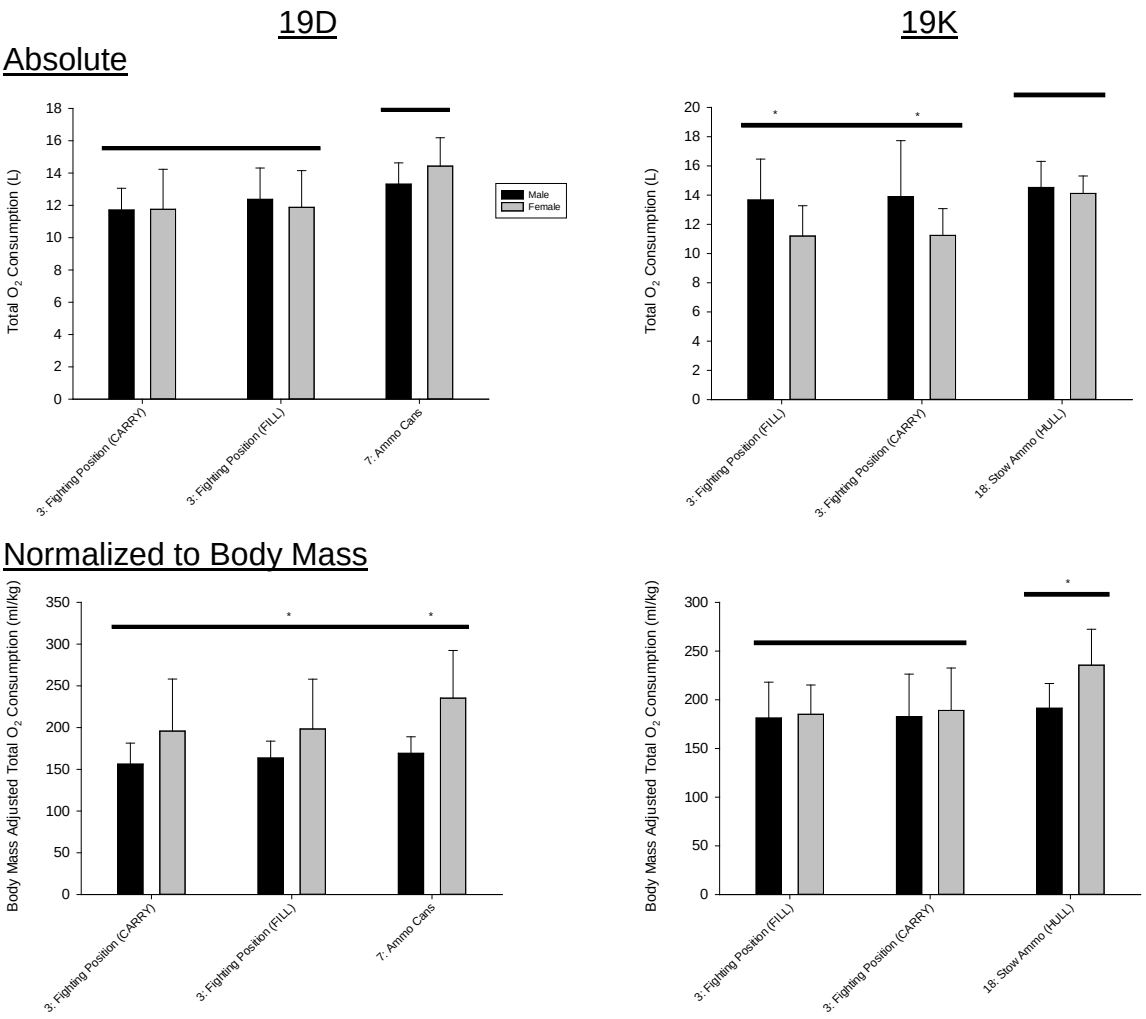
Horizontal bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks. Mean HR only shown for tasks recorded using a metabolic system.

Figure 1.11. Average Absolute (TOP), Body-Mass Normalized (MIDDLE), and Predicted VO_2max Normalized (BOTTOM) Rate of Oxygen Consumption during Aerobic Tasks



Horizontal Bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.

Figure 1.12. Absolute (TOP) and Body-Mass Normalized (BOTTOM) Total Oxygen Consumption during Aerobic Tasks



Horizontal Bars group tasks with similar demands. Bars over single task indicate demands are not similar to any other tasks.

Study 2: Criterion Task Development and Reliability

STUDY 2: INTRODUCTION

In Study 1, the physical demands of the critical physically demanding tasks of Armor Soldiers were defined and compared across tasks. The large number of critical tasks identified for the both MOSs (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 Armor MOSs. 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 range of scores to show differences between people and cannot simply be a pass/fail. Each test 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 test (as much as possible) should require minimal and available equipment and be time efficient. Most importantly, the test needs to be reliable. The same person must get the same score every time they test.

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

The eight 19D and seven 19K physically demanding tasks from Study 1 were divided into four groups based on the physical domains of the tasks: heavy drag, load carriage, maximal heavy lift, and repetitive lift and carry. Based on the physical demands measured in Study 1, tasks from each physical domain were selected to be criterion measure tasks. For both MOS, the casualty drag was selected for the heavy drag and the foot march was selected for the road march. Both were unique, important in protecting the Soldier, and frequently required to perform missions in the field... For both MOS, removing a casualty from a vehicle turret was selected for the heavy lift. The casualty evacuation is the heaviest weight the Soldier 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. In addition, for the 19K, the load the main gun was also included, since it required quick movements and precision to successfully complete the heavy lift. For the repetitive lift and carry, the sandbag carry was selected for the 19D because it had the highest ratings of perceived exertion it was measured to be among the tasks with the highest heart rate and rate of oxygen consumption. In addition, it is common to all Combat Arms MOSs and the equipment is readily available. For the 19K, the stow ammo task on the outside of the tank was selected. The MPAT rounds are heavier than sandbags and more are required to be moved. Furthermore, the lift at the end of each transfer adds a level of difficulty.

A summary of the criteria for selecting the heavy lift task, lift and carry task, and load carriage tasks are summarized in Tables 2.1 and 2.2 for the 19D and 19K, respectively. Thus, the final tasks selected for the 19D were the BFV casualty evacuation, casualty drag, sandbag carry, and foot march. For the 19K, the tasks selected were the Abrams casualty evacuation, casualty drag, load the main gun, outside phase of stow ammo, and foot march.

Four tests from 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 indicates Soldiers reached 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 more closely mimic the ammo can carry (45 lb) while maintaining fidelity with the sandbag carry. Likewise, the stow ammo task was truncated at 18 rounds after looking at a similar VO_2 x repetition curve (Figure 2.2). 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 2.3). Finally the distance for the foot march was shortened based on data collected on four other MOSs (unpublished data) and conversations with SMEs about reducing injuries and trainability of a foot march.

On 9 October 2014, a video teleconference (VTC) was held between USARIEM researchers and the Office of the Chief of Armor (OCOA). The OCOA briefed SMEs 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 Armor Soldiers. 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. Those concerns were communicated back to USARIEM through the OCOA. The SMEs approved of the task selection and the proposed task simulation methods. While not original listed as an Armor task, the SMEs requested that the move under direct fire task be added to the requirement of both MOS. USARIEM agreed and added the task to the list of criterion simulations (see Appendix E for minutes of the VTC presented to SMEs).

STUDY 2: METHODS

Data were collected at Joint Base Lewis-McChord, WA from May 5-16, 2014 (Cohort Alpha) and at Ft. Carson, CO December 8-19, 2014 (Cohorts Bravo & Charlie). A total of 149 active duty Soldiers (79 males, 70 females) were recruited for participation in this portion of the study. These Soldiers were split evenly between both installations such that about 25 males and 25 females participated at each. At Joint Base Lewis-McChord Soldiers were part of the 7th Infantry Division or the 593rd Expeditionary Sustainment Command, and at Ft. Carson Soldiers were part of the 4th Infantry Division. Soldiers held a number of different MOSs. The sample size was determined by using the sample size estimation formula of Hopkins 2000 (16) and data on repetitive lifting tasks from Pandorf 2003 (24), which indicated that 37 Soldiers would be needed to see 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 (height, weight) were also collected prior to testing.

Participating Soldiers were asked to complete a familiarization or practice trial once prior to each testing session. Each task was performed once per day over the course of four testing days. Between different job task simulations, the Soldiers were provided with a minimum of 10 minutes to rest. 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 I and J, respectively.

CRITERION TASK DESCRIPTIONS

Group Alpha: Common MOS Tasks

Sandbag Carry (19D; Repeated Lift and Carry)

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. Soldiers were instrumented with a heart rate monitor. Time to complete the task was collected.

Casualty Drag (19D & 19K; 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 seconds, while wearing a fighting load with a weapon (approximately 83 lb). If the Soldier failed to pull the casualty 15 m in 30 seconds, the distance the casualty was dragged was measured. Scores were calculated as the velocity (m/s) at which the dummy was moved.

Casualty Evacuation from a Vehicle (19D & 19K; Maximal Heavy Lift)

This task was simulated using a platform with a hole designed to simulate the hatch of a BFV and 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 2.4).

Prior to initiating the task, each Soldier practiced proper lifting technique using a pair of kettle bells. 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 minutes 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 was recorded.

Group Bravo: MOS Specific Tasks

Move Under Direct Fire Simulation (19D & 19K; Agility)

During this task, Soldiers wore a fighting load (approximately 83 lb) and carried a simulated weapon at the ready. Soldiers began the task in the prone position. Upon command, Soldiers sprinted approximately 6.6 m to a marker and assume the predetermined position for that marker (either the kneeling or prone position). They remained in this position for 5 seconds. Upon signal, Soldiers will get up and sprinted to the next marker and assume the predetermined position for that marker. The order of the positions was kneel, kneel, prone. This will be repeated until they sprinted a total of 100 m (15 rushes). The course is diagramed in Figure 2.5. Soldiers were instructed to run through the finish line. Time to complete the task was recorded.

Stow Ammunition on Abrams Tank (19K; Repeated Lift and Carry)

While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers moved 18-120mm MPAT rounds (approximately 55 lb each) from a rack simulating an ammunition point onto a platform simulating the deck of an Abrams tank (diagram in Figure 2.6). This platform was 5 m away the ammunition rack and required being lifted 64 inches. A detail Soldier was waiting at the platform to receive the round. Time to complete the task was recorded, and a rate (rounds/min) of loading the rounds was calculated. If Soldiers were unable to complete the task within 15 minutes or chose to stop, the rate was calculated as the number of rounds completed divide by 15 minutes.

Load the 120mm Main Gun on an Abrams Tank (19K; Rapid Heavy Lift)

While wearing 49 lb of task specific equipment, Soldiers loaded five 120mm MPAT rounds (approximately 55 lb each) into a simulated breach of the Abrams tank main gun as quickly as possible (diagram in Figure 2.7). Prior to testing, Soldiers were briefed on proper technique and provided an opportunity to practice. Soldiers then completed the task three times. Time to complete the task was recorded and the fastest two trials were averaged.

Group Charlie: Foot March

Foot March (19D & 19K; Load Carriage)

The load carriage simulation requires Soldiers to complete a movement of 4 miles, 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. 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 (35) 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, 35). Tukey's post-hoc multiple comparison tests was applied to detect significant pairwise differences when significant trial differences were detected by the repeated measures ANOVAs. While there was evidence for a significant learning effect for a number of the tasks ($p<0.05$); however, 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 effects, single-measure reliability model. SEMs are reported in both in 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

Soldier characteristics are provided in Table 2.3. The Soldiers were members of 48 different MOSs (including 13B). Enlisted Soldiers ranged from E2-E7, and there were three officers (two O1, one O2).

RELIABILITY TESTING

Mean scores for each of the task simulations during each test session are provided in Table 2.4. For the Common MOS tasks, the average weight for the casualty evacuation was 154.0 ± 22.1 lb; average time for the sandbag carry was 2.10 ± 0.61 minutes, and average velocity for the casualty drag was 1.07 ± 0.36 m/s. Significant improvements in scores 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. There were no significant differences in individual's scores across trials for the casualty drag.

For the MOS Specific tasks, the average time for the move under fire was 2.26 ± 0.23 min; average rate of the stow ammo was 4.55 ± 2.85 rounds/min, and average time to load the main gun was 26.97 ± 6.94 s. Significant improvements between trials occurred between the first and second trial for all three tasks, second and third trials for the loading the main gun, and the third and fourth trial for the stow ammo and loading the main gun. In addition, for loading the main gun, there was a significant improvement within the three attempts during each testing session.

The average time for the foot march was 80.29 ± 12.09 min. There were no significant changes in performance across trials.

Reliability data are presented in Table 2.5. ICCs of the tasks ranged from 0.76 (95% CI: 0.61-0.86) for the foot march to 0.96 (95% CI: 0.94-0.98) for the casualty evacuation. In terms of the absolute reliability tests, the SEMs ranged from 3% of the mean to 16% (18% if the learning effect is not accounted for). The 95% LOAs were 33% for the sandbag carry time, 0.35 m/s for the casualty drag, 25.7 lb for the casualty evacuation, 0.16 minutes for the move under fire, 2.07 rounds/min for the stow ammo, 21% for load the main gun, and 16.34 minutes for the foot march.

STUDY 2: DISCUSSION

This study identified and established the reliability of the criterion tasks to be used in the development of a testing battery for Armor Soldiers.

TASK SELECTION

The seven 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.

LEARNING EFFECTS

There is evidence for a significant learning effect for a number of the tasks. There were significant improvements for the sandbag carry, casualty evacuation, move under

fire, stow ammo, and loading the main gun between the first and second days. For the sandbag carry, casualty evacuation, move under fire, there were no additional improvements after the second trial. While there was no improvement between the second and third trials of the stow ammo, there was again a significant improvement of between the third and fourth trial. Given the stabilization between the second and third trials and the consistent instruction prior to each trial, this is likely not a learning effect. The improvement is more likely due to either greater motivation or confidence to continue, knowing that it was the final attempt. Load the main gun continued to show improvements over all four sessions. As a result the absolute reliability for the test continued to improve on each trial. Despite the continued improvement, the ICC for the main gun was a 0.93, indicating a consistent improvement across all participants.

Prior to testing of all tasks, Soldiers were given a brief familiarization and practice. Additional familiarization or improvement in the test instructions could mitigate this learning effect. For implementation purposes, a practice for each of these tasks should be provided. On the final test battery, a lower range of passing scores may also need to be accepted to account for this ability to improve with practice.

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 (0.76 (95% CI: 0.61-0.86)) 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 (39); 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 reliability which 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 (24, 35) and 1RM maximal box lifts (35). 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 (35). Likewise, the reliability of the 15-m casualty drag in the present study (ICC 0.90, SEM 11%) were similar to those observed while dragging a casualty 50 m (ICC 0.86, SEM 9%) (35). 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 (23).

LIMITATIONS

When interpreting the reliability of these tasks a number of factors need to be considered. First, many of the 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 and move under fire were completed outdoors. There was no precipitation and temperatures varied from 1-14°C on testing days. Under differing weather locations or courses, the reliability may be less.

There are several other factors which 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 actual task). However, it is unlikely that their influence was completely removed.

STUDY 2: CONCLUSIONS

The selected seven criterion measure tasks reported in this chapter (casualty evacuation, casualty drag, sandbag carry, foot march, move under fire, stow ammo, load the main gun) show high reliability. They have also been approved by SMEs as accurately capturing the physical demands of Armor tasks. Thus, they are appropriate for use in the development of a predictive battery to select Armor Soldiers for training.

STUDY 2: RECOMMENDATIONS

- The five 19D and six 19K criterion 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 test instructions should be applied to the sandbag carry, casualty evacuation, move under fire, stow ammo, and load the main gun tasks in order to minimize any learning effect.

- This approach to determining the reliability of soldiering tasks may be useful for additional tasks.

Table 2.1. Factors Considered during Down-Selection of 19D Criterion Measure Tasks

Heavy Lifting Tasks				
	25mm Barrel Install	**Feeder Assembly**	**Load TOW Missile**	**BFV Casualty Evacuation**
Covers weight range of other heavy lifting tasks				X
Common to other Combat MOS	X	X	X	X
Can be Individual Test		X	X	X
Minimal Skill or Training	X			X
Equipment Readily Available				
Critical to Safety and/or Mission Success				X
Repeated Lift and Carry Tasks				
	Sandbag Fill (Wt.: 35 lb)	**Sandbag Carry (Wt.: 35 lb)**	**Ammo Can Carry (Wt.: 45 lb)**	
Greater Perceived Exertion		X	X	
Greater Heart Rate			X	
Greater Energy Cost		X	X	
Common to other Combat Arms MOSs		X	X	
Equipment Readily Available	X	X	X	
Requires Significant Grip Strength			X	

Table 2.2. Factors Considered during Down-Selection of 19K Criterion Measure Tasks

Heavy Lifting Tasks				
	Mount .50 Caliber	**Abrams Casualty Evacuation**		
Covers weight range of other heavy lifting tasks		X		
Common to other Combat MOS		X		
Can be Individual Test	X	X		
Minimal Skill or Training	X	X		
Equipment Readily Available				
Critical to Safety and/or Mission Success	X	X		
Repeated Lift and Carry Tasks				
	Sandbag Fill (Wt.: 35 lb)	**Sandbag Carry (Wt.: 35 lb)**	**Stow Ammo-Outside (Wt.: 55 lb)**	**Stow Ammo-Inside (Wt.: 55 lb)**
Greater Load Carried			X	X
Greater Perceived Exertion	X	X	X	X
Greater Heart Rate		X	X	
Greater Energy Cost		X	X	
Common to other Combat Arms MOSs	X	X		
Equipment Readily Available	X	X		
Requires Significant Grip Strength		X		
Significant Learning Required				X

Table 2.3. Soldier Characteristics: Study 2

Group Alpha: Common MOS Tasks* *Sandbag Carry, Casualty Drag, and Casualty Evacuation*	**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-ups (# / 2 min)	67.6 ± 12.2	42.8 ± 12.1	<0.01
Sit-ups (# / 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_2max (ml/kg/min)	51.7 ± 5.1	49.1 ± 6.3	0.12

Group Bravo: MOS Specific Tasks* *Move Under Direct Fire, and Transfer Ammo with a FAASV*	**Males (n=25)**	**Females (n=25)**	**p-value**
Age (years)	24.3 ± 4.1	22.6 ± 3.0	0.11
Height (cm)	178.9 ± 6.6	164.3 ± 7.3	<0.01
Mass (kg)	82.5 ± 9.8	65.2 ± 8.6	<0.01
Time in Military (years)	3.7 ± 3.2	2.9 ± 2.7	0.29
Time in MOS (years)	3.3 ± 2.2	2.5 ± 2.3	0.24
Number Deployed (%)	13 (52%)	7 (28%)	–
Time Deployed (years) *for only those who have deployed*	1.1 ± 0.6	1.5 ± 1.2	0.36
Army Physical Fitness Test Score (points)	267.8 ± 20.3	272.2 ± 26.5	0.51
Push-ups (# / 2 min)	67.7 ± 9.5	46.5 ± 11.7	<0.01
Sit-ups (# / 2 min)	72.4 ± 10.3	70.0 ± 10.7	0.45
Two-Mile Run Time (min)	14.1 ± 1.1	16.5 ± 1.3	<0.01
Predicted VO_2max (ml/kg/min)	52.4 ± 3.8	49.9 ± 4.4	0.04

Table 2.3. Soldier Characteristics: Study 2 (continued)

Group Charlie: Foot March	**Males (n=29)**	**Females (n=20)**	**p-value**
Age (years)	23.0 ± 3.3	25.3 ± 4.7	0.05
Height (cm)	176.9 ± 6.5	169.1 ± 6.6	<0.01
Mass (kg)	80.2 ± 12.1	68.6 ± 7.9	<0.01
Time in Military (years)	3.3 ± 2.4	2.7 ± 1.7	0.33
Time in MOS (years)	3.0 ± 2.4	2.6 ± 1.7	0.47
Number Deployed (%)	16 (55%)	9 (45%)	–
Time Deployed (years) *for only those who have deployed*	1.1 ± 0.7	0.9 ± 0.3	0.42
Army Physical Fitness Test Score (points)	270.1 ± 19.0	266.6 ± 23.5	0.57
Push-ups (# / 2 min)	71.8 ± 11.1	43.3 ± 11.4	<0.01
Sit-ups (# / 2 min)	71.7 ± 10.1	68.4 ± 13.9	0.35
Two-Mile Run Time (min)	13.3 ± 2.8	15.8 ± 4.0	0.01
Predicted VO_2max (ml/kg/min)	53.6 ± 4.4	48.6 ± 5.8	<0.01

Table 2.4. 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 Casualty 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
Move Under Fire (min)	**M**	25	**2.14 ± 0.08***	25	2.12 ± 0.11	24	2.09 ± 0.09	22	2.12 ± 0.10
	F	24	**2.45 ± 0.26***	24	2.42 ± 0.20	22	2.40 ± 0.23	21	2.39 ± 0.26
Stow Ammo (rounds/min)	**M**	25	**5.93 ± 1.17***	25	6.82 ± 1.47	24	7.08 ± 1.56	22	7.19 ± 1.78
	F	24	**1.00 ± 1.45***	24	2.17 ± 1.18	22	2.52 ± 1.75	21	3.45 ± 2.00
Load the Main Gun (sec; average best 2 of 3 trials)	**M**	25	**21.4 ± 4.49***	25	**17.5 ± 4.73***	24	**15.5 ± 2.76***	23	14.6 ± 2.94
	F	25	**29.7 ± 9.16***	24	**24.6 ± 5.82***	22	**22.6 ± 5.53***	21	20.4 ± 4.49
Foot March (min)	**M**	29	76.8 ± 5.84	29	74.6 ± 9.32	27	72.1 ± 7.65	20	74.4 ± 9.05
	F	21	92.7 ± 11.3	19	89.7 ± 12.6	17	86.3 ± 11.5	13	85.4 ± 12.4

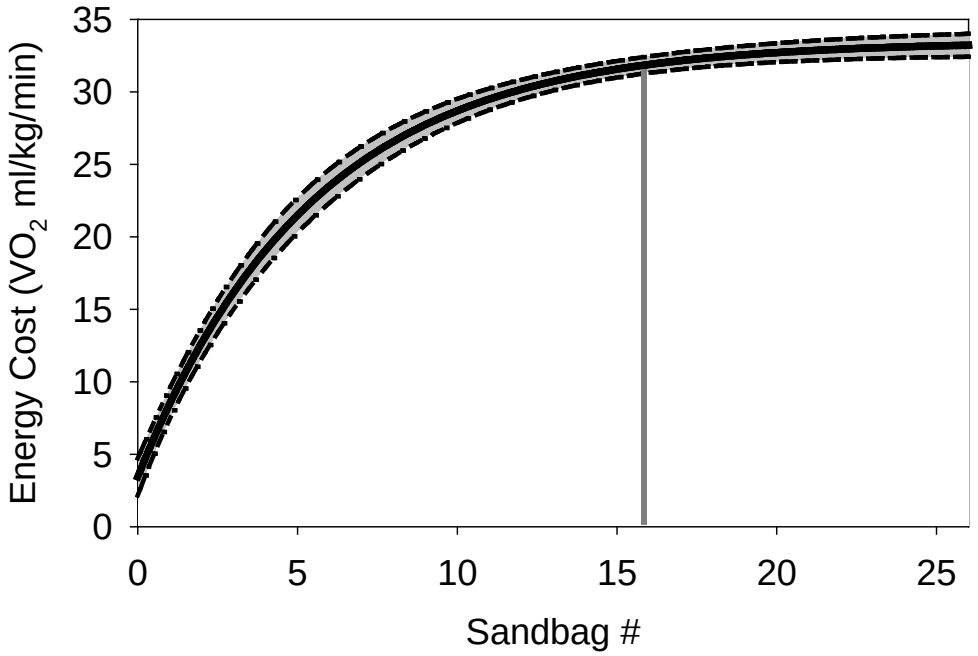
*** Significantly different from following trial, p<0.05**

Table 2.5. 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 (12%)	0.75	
		2 vs 3	0.85 [0.75-0.91]	0.25 (12%)		33%
Casualty Drag (m/s)	50	1 vs 2	0.90 [0.83-0.94]	0.13 (11%)	0.35	
BFV Casualty Evacuation (lb)	49	1 vs 2	0.94 [0.90-0.97]	15.25 (10%)	32.9	
		2 vs 3	0.96 [0.94-0.98]	9.26 (6%)	25.7	
Move Under Fire (min)	49	1 vs 2	0.90 [0.82-0.94]	0.08 (3%)	0.21	
	46	2 vs 3	0.93 [0.88-0.96]	0.06 (3%)	0.16	
Stow Ammo (rounds/min)	49	1 vs 2	0.94 [0.89-0.96]	0.72 (18%)	1.97	
	46	2 vs 3	0.93 [0.88-0.96]	0.75 (16%)	2.07	
Load the Main Gun (s)	49	1 vs 2	0.84 [0.73-0.90]	2.82 (12%)		33%
	46	2 vs 3	0.90 [0.83-0.94]	1.92 (10%)		27%
	44	3 vs 4	0.93 [0.88-0.96]	1.36 (7%)		21%
Foot March (min)	48	1 vs 2	0.76 [0.61-0.86]	5.89 (7%)	16.34	

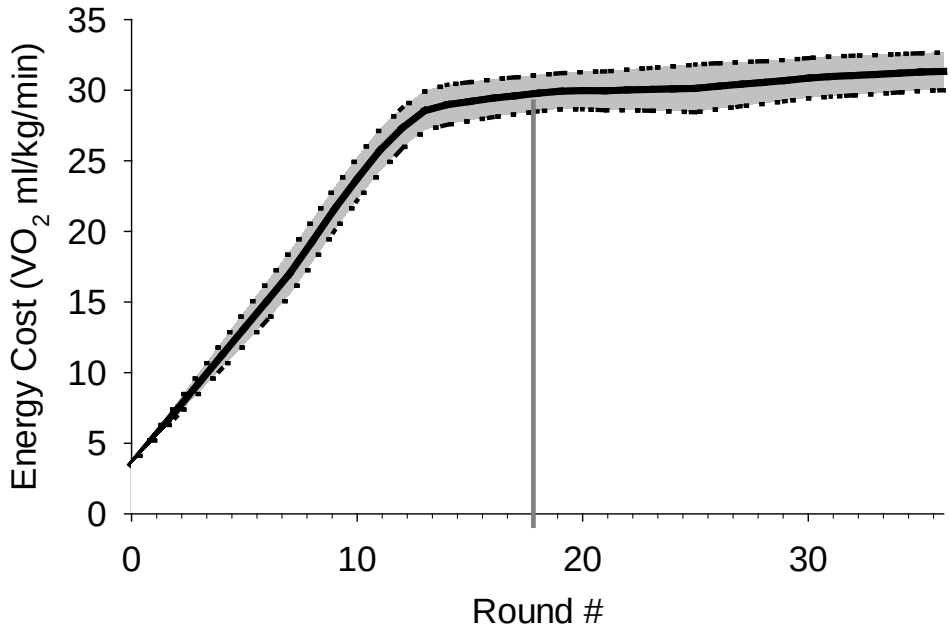
Due to a significant learning effect for sandbag carry, casualty evacuation, move under fire, and stow ammo, 1 vs 2 indicate reliability including learning effect, while 2 vs 3 is without a learning effect. Loading the main gun showed learning effects across all 4 trials.

Figure 2.1. Energy Cost over Time of the Sandbag Carry Task from Study 1



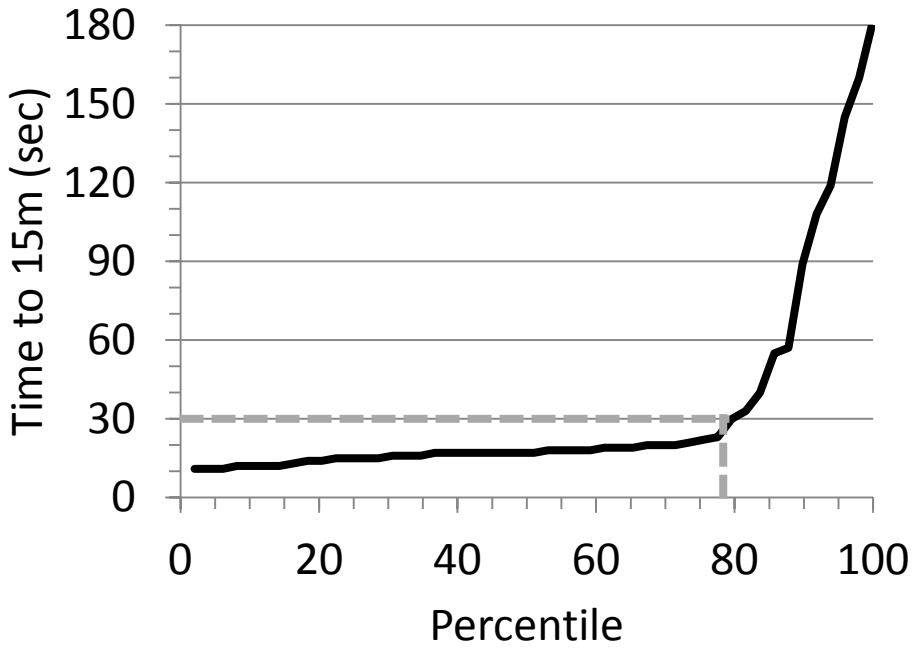
Solid line: Mean
Vertical line: Proposed Cutoff
Shaded area: 95% Confidence Interval of Mean

Figure 2.2. Energy Cost over Time of the Stow Ammo Task from Study 1



Solid line: Mean
Vertical line: Proposed Cutoff
Shaded area: 95% Confidence Interval of Mean

Figure 2.3. Distribution of Dummy Drag Times from Study 1



Dashed line represents maximal time allowed for criterion testing.

Figure 2.4. Diagrams and Photos of the Casualty Evacuation Simulation

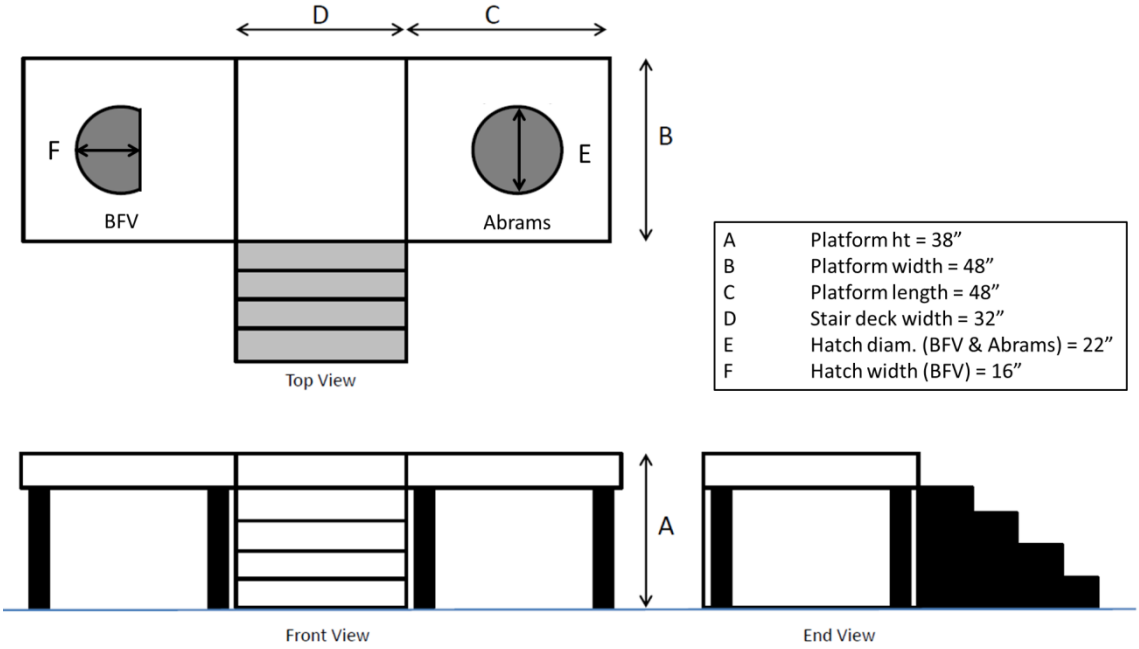


Figure 2.5. Diagram and Photos of the Move Under Direct Fire Simulation

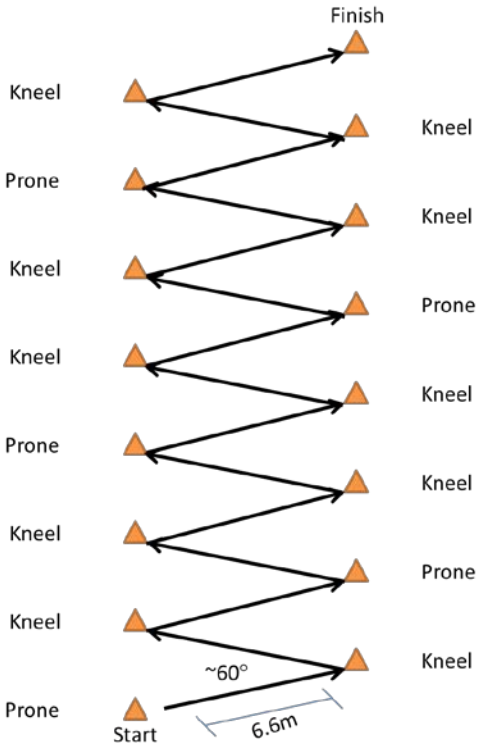
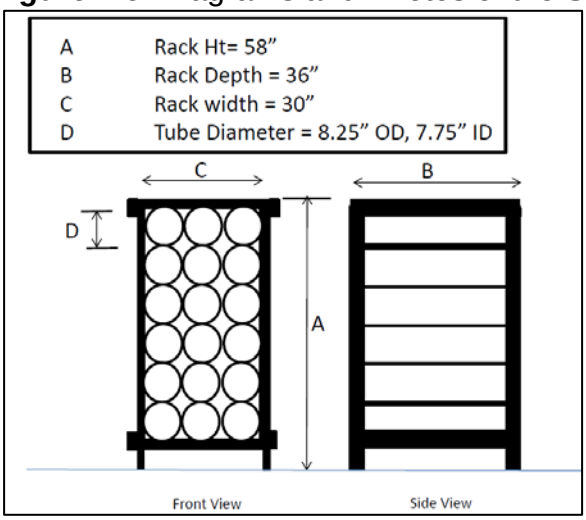


Figure 2.6. Diagrams and Photos of the Stow Ammo Simulation



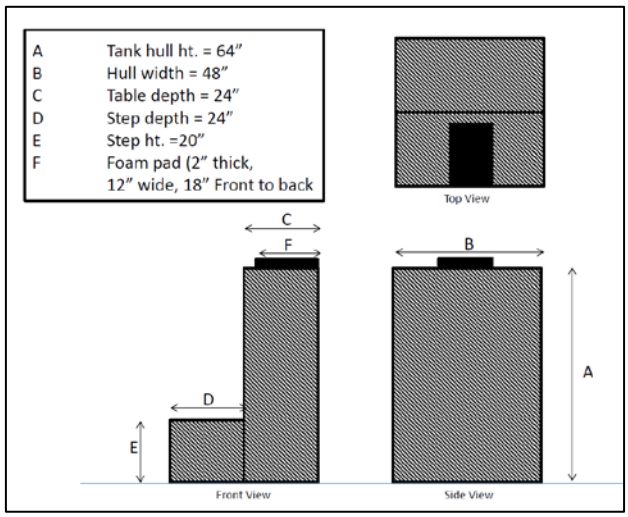
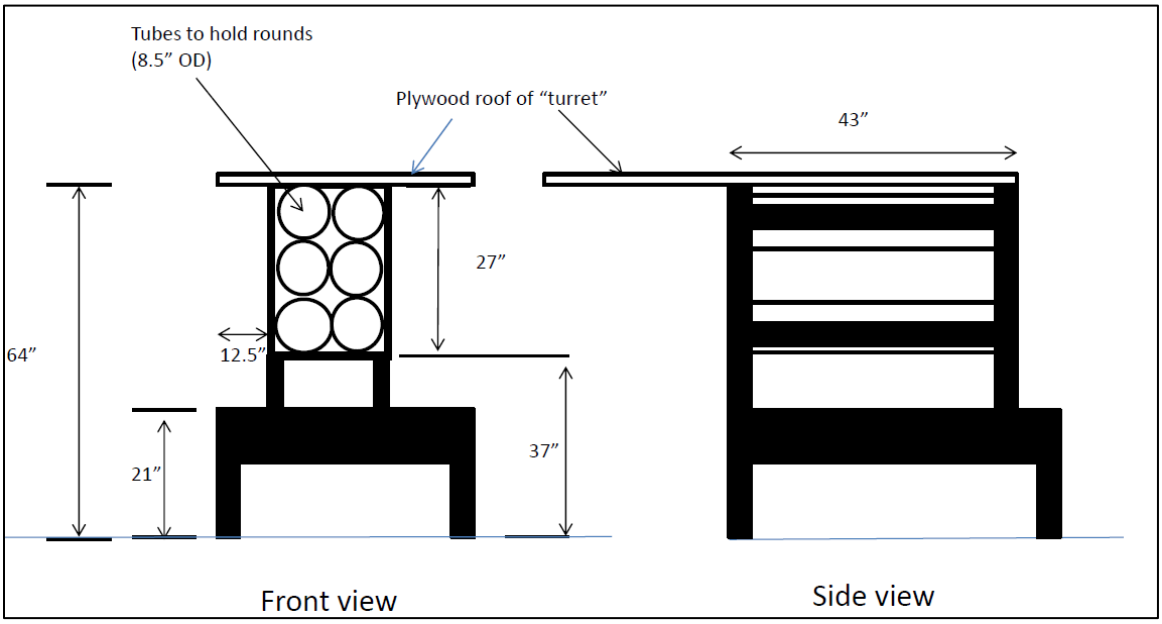
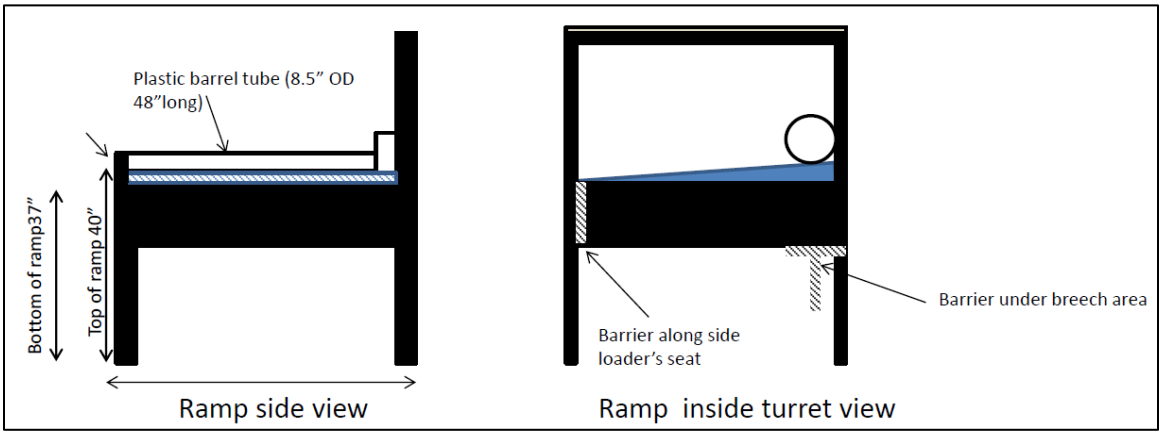


Figure 2.7. Diagrams and Photo of the Load the Main Gun Simulation





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, use of predictor tests that include skills that are learned in training or on the job do 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 associated 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-mile run from the UK (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 Armor MOSs (19D Armor Crewman and 19K Cavalry Scout).

Limited information is available to determine the relationship between field-expedient physical tests and MOS-specific task performance of U.S. Soldiers. This may be due to the current lack of well-defined physical performance standards or criterion tasks for the Combat Arms MOSs. Previous 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, 37). Furthermore, these predictive models included sex 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 19D and 19K MOSs.

STUDY 3: METHODS

Data for the 19D were collected in April 2015 at Ft. Carson, CO. For the19K, data collection was split between two sites: Ft. Stewart, GA in April/June 2015; and at Ft. Riley, KS in June 2015. Collection was split between the two sites in order to recruit the necessary sample size. A total of 339 active duty Soldiers (181 Male, 158 Female) were recruited for participation in this portion of the study. All male Soldiers held the 19D

Cavalry Scout or 19K M1 Armor Crewman MOSs, while the female Soldiers were recruited from any MOS. Soldiers were of the 4th Infantry Division (Ft. Carson), 3rd Infantry Division (Ft. Stewart) and 1st Infantry Division (Ft. Riley).

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. Each Soldier's height and weight in ACUs were collected prior to testing. Characteristics of the Soldiers tested are provided in Table 3.2. While all of the males were 19D and 19Ks, female Soldiers were members of 47 different MOSs. Enlisted Soldiers ranged from E1-E7, and there were one male officer (O1) and seven female officers (six O1, one O2).

Sample size estimates were run using SamplePower 3.0.1 (IBM Corp, Armonk, New York). For any single task, 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 variable regression at a moderate effect size ($R^2 = 0.13$, (8)). A sample of females was also included in order to test for any differential effects of sex.

TESTING OVERVIEW

Testing for the 19D and 19K consisted of the five and six criterion tasks, respectively, along with 14 predictor tests. For the 19D, the five criterion tasks were the foot march, prepare a fighting position- sandbag carry, casualty drag, casualty evacuation, and move under direct fire. The six 19K criterion tasks were foot march, casualty drag, casualty evacuation, move under direct fire, stow ammunition in an Abrams tank, and load the main gun. The following are the 14 predictive tests that were administered: beep test, Illinois agility test, standing long jump, handgrip, upright pull at 38cm, medicine ball put, isometric biceps curl, 1-minute sit-up, 1-minute push-up, powerball throw, 300m sprint, squat lift, resistance pull with a sled, and an arm ergometer test.

TESTING PROCEDURES

All criterion tasks from both MOSs were administered as described in Study 2 (see previous chapter). All testing instructions and data sheets for Study 3 can be found in Appendices K and L, respectively. The predictor tests were administered as follows:

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 beeps became closer

together. 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 (21).

Illinois Agility Test (Figure 3.1)

The length of the course is 10 m and the width (distance between the start and finish points) is 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 (14).

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 will were allowed. The two furthest distances jumped (cm) were averaged (19).

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 3-5 seconds. 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 at 38 cm

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-minute 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 (18).

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 (15).

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 3-5 seconds. 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 (38), 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-degree angle. Their feet could be up to 12 inches apart and were held down by a second individual. Soldier's 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 sit-ups as possible in one minute.

One Minute Push-Up

The push-up test used the same rules as the APFT (38), with the exception that the test was only one minute in duration. Briefly, Soldiers began with their arms straight, hands a comfortable distance apart, and body straight. Soldier's feet could be up to 12 inches 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 push-ups as possible in one minute.

Powerball Throw

The powerball throw test required throwing a 20-lb medicine ball for a maximum distance to measure total body power. Soldiers began the test by standing with their heels on the starting line and facing the opposite direction in which the ball would be thrown. They held the ball with both hands and while keeping their arms extended they brought the ball down between their legs with bent knees. In one motion, they threw the ball up and back over their head. The distance from the starting line to the point at which the ball landed was measured. Soldiers completed two practice throws and three trials for record. If there was more than a 10% difference in the two highest scores, they were

provided up to two additional trials. If Soldiers stepped backwards over the throwing line from which the throw distance was measured prior to releasing the ball, the trial was repeated (36)

300m 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.

Squat Lift

This test is intended to measure lower-body strength. The lifts were performed using pairs of weights (dumbbells) ranging from 25-110 lb (total weight: 50-220 lb). The Soldiers were provided instructions on proper lifting technique prior to beginning the test. Beginning by standing with their feet shoulder-width apart, Soldiers squatted and grasped the handles of the weights at their sides, and performed a squat lift. A warm up weight of 50 lb (two 25-lb dumbbells) was used for three lifts and coaching was provided to ensure safe lifting technique. For testing, the weight started at 60 lb and increased by 20 lb (10 lb per dumbbell), with at least 1-minute of rest between trials, until the Soldier could no longer lift the dumbbell with proper lifting technique or they reached the maximum weight of 220 lb.

Resistance Pull with Sled

To assess total body pulling power, Soldiers held the handle of a 24-kg kettlebell attached with a strap to a plate loaded sled (approximately 95-100 lb) (Magic Carpet Sled, Spud, Inc., Columbia, SC) and pulled it for 20 m and/or 90 seconds, which ever came first. Soldiers were instructed to pull the kettlebell attached to the strap while stepping backwards as quickly as possible. A maximum time limit of 90 seconds was set. If the Soldier failed to pull the sled a distance of 20 m in the 90 seconds allotted time, the distance completed was measured and recorded. Time to complete and distance were recorded and converted to speed for imputation into the predictive model(s).

2-Minute Arm Ergometer (Figure 3.2)

Soldiers cranked an Arm Ergometer (Model 881E, Monark AB, Varberg, Sweden) as fast as possible, for two minutes. 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 (12, 13).

Subject Matter Expert Observations:

Subject Matter Experts (SMEs) were identified by TRADOC to observe and rate each Soldier's performance as they completed each of the criterion task simulations (Appendix N). The SMEs were not in the supervisory chain of participating Soldiers. The

purpose of these ratings was to rate the speed (pace) and ability of each Soldier to determine where their performance fell in comparison to other Soldiers in that MOS.

STATISTICAL ANALYSES

Descriptive statistics were calculated for each task to characterize group performance on each test. Correlation coefficients appropriate to score distributions were computed to quantify strength of association among test variables.

Unpaired T-tests were used to compare group characteristics by gender. Descriptive statistics were calculated for each task to characterize each sex, as well as group performance on each test. Criterion task test scores were converted to z-scores in order to create a common scale for all criterion tasks. Z-scores for the tactical movement, sandbag carry, move under direct fire, and load the main gun were inverted (i.e. multiplied by -1) so that better scores were greater numbers. 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 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

Soldier characteristics are provided in Table 3.2. For the 19D cohort, males were taller and heavier than females ($p<0.01$). Males had spent more time in the MOS ($p=0.01$). Males and females had similar APFT scores ($p=0.17$), but males had higher push-up and faster 2-mile run raw scores ($p<0.01$). There was no sex difference in estimated VO_2max.

For the 19K cohort, males were also taller and heavier than the females ($p<0.01$). The females were on average 1.5 years older than the males ($p=0.01$). As with the 19D cohort, males and females of the 19K cohort had similar APFT scores ($p=0.42$), but males had higher push-up and faster 2-mile run raw scores ($p<0.01$). In this cohort, the females had a lower estimated VO_2max ($p<0.01$).

TESTING PERFORMANCE

Summaries and distributions of scores for the 19D criterion job tasks are provided in Table 3.3. Z-score distributions for the 19D criterion job tasks, as well as the total summed performance Z-score, are provided in Table 3.4. For the predictor tests performance for the 19D, summaries and distributions are shown in Table 3.5. For the 19K, performances on the criterion job tasks are provided in Table 3.6 for the raw scores and Table 3.7 for the Z-scores. Predictor test summaries are found in Table 3.8.

Additional statistical analyses for both MOSs can be found in Appendix M.

19D PREDICTION MODELS

Bivariate correlations amongst the criterion tasks and predictor tests for the 19D are provided in Table 3.9. The only non-significant correlations were amongst the sit-ups with the following three criterion tasks: sandbag carry, casualty evacuation and casualty drag.

Five performance predictor models (Table 3.10) were developed using data from 134 Soldiers for whom complete datasets were available:

- The first model included all of the predictor tests with the following six predictors tests as significant predictors (Full Model Adjusted $R^2 = 0.85$, $p<0.01$): squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, arm ergometer.
- A second model omitted the arm ergometer, as the cost of the device may be prohibitive. The significant predictors in this model were the squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, and resistance pull sled (Full Model Adjusted $R^2 = 0.85$, $p<0.01$).
- 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 excluded the arm ergometer, handgrip, upright pull, and biceps curl tests as potential covariates. The resulting 4-predictor model consisted of the Squat Lift, standing long jump, beep test, and medicine ball put (Full Model Adjusted $R^2 = 0.84$, $p<0.01$).
- Two models consisted of tests which only required a stopwatch and tape measure. The first of the two models used five predictors: standing long jump, beep test, 1-minute sit-up, 1-minute push-up, and Illinois agility (Full Model Adjusted $R^2 = 0.70$, $p<0.01$).
- The final model reduced the stopwatch and tape measure model to four predictors by eliminating the Illinois agility test. This model consisted of the standing long jump, beep test, 1-minute sit-up, and 1-minute push-up (Full Model Adjusted $R^2 = 0.69$, $p<0.01$).

Correlations of the five models with the individual criterion tasks ranged from r = 0.88-0.68, with the foot march having the lowest correlations (r = 0.74-0.68) and the casualty evacuation (r = 0.88-0.77) 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 3.11. Additional statistics on the models are provided in Appendix M.

19K PREDICTION MODELS

Bivariate correlations amongst the criterion tasks and predictor tests are provided in Table 3.12. All of the correlations amongst the criterion tasks and predictor tests were significant.

Five performance predictor models (Table 3.13) were developed using data from 187 Soldiers for whom complete datasets were available:

- The first model included all of the predictor tests. In this model, medicine ball put, arm ergometer, Illinois agility, squat lift, and beep test came out as significant predictors (Full Model Adjusted $R^2 = 0.85$, $p<0.01$).
- A second model included only four predictor tests by eliminating the beep test: medicine ball put, arm ergometer, Illinois agility, and squat lift (Full Model Adjusted $R^2 = 0.85$, $p<0.01$).
- The third model omitted the arm ergometer, as the cost of the device may be prohibitive. The significant predictors in this model were the medicine ball put, 300 m sprint, squat lift, 1-minute push-up, and resistance pull (Full Model Adjusted $R^2 = 0.82$, $p<0.01$).
- The fourth model also eliminated the arm ergometer and but reduced the model to four predictors: medicine ball put, 300m sprint, squat lift, and 1-minute push-up (Full Model Adjusted $R^2 = 0.80$, $p<0.01$). No additional model was run to exclude all calibrated equipment because the two models excluding the arm ergometer did not include any predictors requiring calibration.
- The final model consisted of tests which only required a stopwatch and tape measure. This model excluded the arm ergometer, handgrip, upright pull, and biceps curl tests as potential covariates. The resulting model consisted of the 300m sprint, Illinois agility, 1-minute push-up, and standing long jump (Full Model Adjusted $R^2 = 0.71$, $p<0.01$).

Correlations of the five models with the individual criterion tasks ranged from r = 0.90-0.54, with the foot march having the lowest correlations (r = 0.63-0.54) and the casualty drag (r = 0.90-0.79) having the highest. 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 3.14. Additional statistics on the models are provided in Appendix M.

STUDY 3: DISCUSSION

This study validated the ability of 14 simple physical tasks to predict performance of at least one of the MOS-specific criterion tasks. From those tests, a collection of four to five potential testing models were constructed to predict physical performance on the 19D and 19K criterion tasks. All 10 (five 19D, five 19K) of the models have $R^2 \geq 0.60$, the generally accepted lower limit for such models. While not exactly the same, most of the models capture similar fitness requirements to those developed by other countries (Table 3.15).

INDIVIDUAL PREDICTORS

Of the 14 predictor tests, 13 were significantly predictive of all criterion tasks. The only exception was the sit-up task, which did not significantly correlate with performance of any of the tasks with the exception of the 19D move under fire task. 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- 19D

For the 19D, five possible outcome models were provided multiple situations. All eight of the models showed significant predictive power and were stronger than a model based solely on APFT performance ($R^2 = 0.60$, *data not shown*).

The first model, which included all the covariates, is the best predictor of performance on the criterion tasks based on the predictors tested ($R^2 = 0.86$). This test battery includes the squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, and arm ergometer. Notably, this model consists of tests that capture six different aspects of fitness. The squat lift tests lower-body strength; standing long jump tests lower-body power; beep test captures cardiovascular endurance; medicine ball put tests upper-body power; 1-minute sit-up assess core endurance; and the arm ergometer captures upper-body endurance. While this model is optimal from a predictive viewpoint, it does not take into account any limitations in terms of space, budget, or training and maintenance required to use some the equipment. The arm ergometer is space efficient, 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 realistic. The medicine ball put requires about a 3-m high ceiling and 10-15 m of open area as a landing site for the medicine ball. The squat lift test requires the use of several heavy dumbbells in order to be performed, which could be expensive. While the beep test does not require a lot of equipment, it does demand a large stretch of space (over 20 m in length). The second model provides six predictor tests, without the cost of an arm ergometer. This second testing battery maintains much of the same overall predictive power as the first model ($R^2 = 0.85$), with the sled drag replacing the arm ergometer. While there is some reduction in cost with this replacement, as the sled drag requires rubber matting in order to maintain a consistent surface. A lot of time could be spent placing and storing the rubber mats if space is at a premium.

The third model eliminates the need for any calibrated equipment that is not readily purchased at a sporting goods store ($R^2 = 0.84$). This model resulted in a test battery consisting of four tests: squat lift, standing long jump, beep test, and medicine ball put. This model maintains similar predictive power as the two previously mentioned models while being more cost effective. This makes it a much cheaper option to

implement; however, the demand of space and cost to administer the beep test, squat lift and medicine ball put is still a factor to consider.

The final two model eliminate the need to purchase any equipment other than a stop watch and a tape measure using five predictor tests ($R^2 = 0.71$). This model produced a test battery that includes standing long jump, beep test, 1-minute sit-up, 1-minute push-up (upper-body strength and endurance), and Illinois agility test (lower-body movement quality). There was a large decrease in predictive power from the previously mentioned models to this current model, but the predictive power is still above the generally accepted cut score. This set of predictor tests requires minimal equipment resulting in a cost-effective model; however, the space cost requirements are still needed for the beep test and squat lift. Eliminating the Illinois agility test to make a four predictor test model results in a negligible drop in R^2 ($R^2 = 0.70$) while also decreasing the time required for testing.

PREDICTION MODELS- 19K

Five possible prediction models were also provided to help predict performance of the selected 19K criterion tasks. Again, all of the models for the 19K showed significant predictive power, and were much stronger than a model based solely on APFT performance for ($R^2 = 0.54$, *data not shown*).

The first model, which included all the covariates, is the best predictor of performance on the criterion tasks based on those predictors tested ($R^2 = 0.86$). This test battery includes the medicine ball put, arm ergometer, Illinois agility, squat lift, and beep test. This model consists of tests that capture various aspects of fitness: lower-body strength (squat lift) and endurance (beep test), upper-body power (medicine ball put) and endurance (arm ergometer), and movement quality (Illinois agility). This model is optimal for predictive accuracy; however it is possible to develop predictive models, albeit with more predictive error, which have fewer requirements (i.e., space, budget, training, and maintenance). The squat lift test requires the use of several heavy dumbbells in order to be administered. The arm ergometer has been successfully implemented as pre-employment screening testing for other organizations as it is space efficient, 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 is a limitation of this predictor test. A second similar model simplifies model one by eliminating the beep test. This model maintains approximately the same predictive power as the first model ($R^2 = 0.86$), but only four tests are needed to be administered.

The third model excludes the arm ergometer to create a testing battery using five predictor tests: medicine ball put, 300m sprint (lower-body anaerobic power), squat lift, 1-minute push-up (upper-body endurance), and resistance pull (lower-body power and strength). This testing battery has only a slight decrease in predictive power of the first model ($R^2 = 0.86$ v. 0.83), without the necessity and expenses of an arm ergometer. Additionally, there is no calibrated equipment in this model, as all the equipment needed for this model could be purchased easily at a sporting goods store. The medicine ball put does require a space with high ceilings and an open area for medicine ball landing

points. Eliminating the resistance pull reduces the cost and time to perform the test battery, while resulting in another slight decrease in predictive power ($R^2 = 0.81$).

The final 19K model includes tests that can be administered using only a stop watch and tape measure ($R^2 = 0.71$). This model resulted in a test battery consisting of four tests: the 300 m sprint, Illinois agility, 1-minute push-up (captures upper-body strength and endurance), and standing long jump (a measure of lower-body power). There was a considerable increase in predictive error from the previously mentioned models to this current model, but the predictive power is still above the generally accepted cut score. Also of note, is the duplication in physical domains, as both the 300m sprint and the standing long jump effectively are both measuring lower-body power. Although this model provides substantial benefits in the ease of testing, the loss in predictive accuracy make it the least suitable model for identifying individuals who could succeed in the MOS.

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. Since 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_2peak and lower-body strength have been shown following 8 weeks of BCT (33).

From here, it will be possible to identify cut-scores for the predictive tests. There will be some error in the predictions since no model is perfect. Thus, it may be necessary to adjust the cut-scores to optimize the number of individuals who are incorrectly identified as passing or failing a test. By selecting a higher standard to represent in superior performance, this will decrease the number of false positives but also increase the number of false negatives. 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 (13). 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 at least 60/100 points on all four tests). With the compensatory model, recruits must reach a total score based on the predictors, but they may make up for a poor performance on one predictor 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 Armor recruits is crucial for the full validation of the model. The test should be administered to all Soldiers entering the 19D and 19K MOSs 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 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 models developed for both the 19D and 19K MOSs 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 important element: the correct selection of the criterion tasks. The job performance score being predicted is based on the five 19D and six 19K criterion tasks. While our research indicates that these are the appropriate criterion tasks and capture many aspects of the physically demanding tasks of the 19K and 19D, 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 five models for the 19D and five models 19K MOSs in order to effectively predict performance on MOS-specific criterion tasks that were identified in Studies 1 and 2. For the 19D, the strongest model included squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, and arm ergometer predictor tests. The strongest model for the 19K included medicine ball put, arm ergometer, Illinois agility, squat lift, and beep test predictor tests. The other models that are provided serve as sufficient alternatives based on cost, feasibility, and equipment availability.

STUDY 3: RECOMMENDATIONS

- The Army should select one of the provided designated MOS models, based on the equipment availability and willingness to purchase for use.

  The five models for 19D were (from best to worst predictive ability):
  - squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, and arm ergometer

- squat lift, standing long jump, beep test, medicine ball put, and resistance pull
- squat lift, standing long jump, beep test, medicine ball put
- standing long jump, beep test, 1-minute sit-up, 1-minute push-up, Illinois agility
- standing long jump, beep test, 1-minute sit-up, 1-minute push-up

The five models for 19K were (from best to worst predictive ability):

- medicine ball put, arm ergometer, Illinois agility, squat lift, and beep test
- medicine ball put, arm ergometer, Illinois agility, squat lift
- medicine ball put, 300m sprint, squat lift, 1-minute push-up, resistance pull
- medicine ball put, 300m sprint, squat lift, 1-minute push-up
- 300m sprint, Illinois agility, 1-minute push-up, standing long jump

- Follow-up studies should confirm the validity of this model in a separate group of Soldiers.
- In order to establish cut-points, acceptable scores on the criterion tasks need to be verified and/or established, which can then be used to identify critical scores on the predictor tests.
- 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 accuracy of the model. Longitudinal follow-ups should be considered on a routine basis to ensure the continued acceptability of the prediction model.
- Before selecting on of the above testing batteries, models that incorporate the same test of other Combat Arms MOSs (i.e., 11B, 11C, 12B, 13B, 13F) should be explored and considered for use as the Pre-Employment Screening Test.

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 • Load Carriage • Combat Rushes • Jerry Can Carry • Heavy Equipment Lift Artillery • All Corps + moving ammunition for a M777A2 conducting a 10-round fire for effect Infantry • All Corps + Casualty Drag	All Corps • Weight Load March • Fire and Movement • Jerry Can Carry • Box Lift and Place Artillery • All Corps + repeatedly lift and carry 10m an inert artillery round Infantry • All Corps + Simulated Casualty Drag
Canada (6, 9, 29)	• Escape to Cover • Sandbag Fortification • Pickets and Wire Carry • Picking and Digging • Vehicle Extrication • Stretcher Carry	• Sandbag Lift • Intermittent Loaded Shuttles • 20-M Rushes • Sandbag Drag
United Kingdom (5, 27, 28)	• Jerry Can Carry • Load Carriage • Single Ammo Box Lift	• 1.5-Mile Run/Beep Test • Jerry Can Carry • Static Lift • Sit-up • Push-up

Table 3.2. Soldier Characteristics: Study 3

19D Cohort	**Males (n=85)**	**Females (n=49)**	**p-value**
Age (years)	24.3 ± 4.0	24.1 ± 4.3	0.77
Height (cm)	179.6 ± 7.1	165.6 ± 6.6	<0.01
Mass (kg)	84.6 ± 12.8	65.2 ± 8.3	<0.01
Time in Military (years)	3.8 ± 2.6	2.7 ± 2.0	0.01
Time in MOS (years)	3.4 ± 2.0	2.6 ± 2.2	0.04
Number Deployed	75 (88%)	16 (33%)	–
Time Deployed (years) *for only those who have deployed*	0.9 ± 0.6	0.8 ± 0.6	0.82
Army Physical Fitness Test Score (points)	262.7 ± 27.8	269.7 ± 28.6	0.17
Push-ups (# / 2 min)	69.0 ± 12.7	46.1 ± 9.1	<0.01
Sit-ups (# / 2 min)	72.0 ± 10.3	73.5 ± 9.7	0.40
Two-Mile Run Time (min)	14.3 ± 1.2	16.6 ± 1.4	<0.01
Predicted VO_2max (ml/kg/min^{-1})	51.3 ± 5.3	49.8 ± 4.3	0.12
19K Cohort	**Males (n=95)**	**Females (n=93)**	**p-value**
Age (years)	23.1 ± 3.4	24.6 ± 5.1	0.01
Height (cm)	178.5 ± 6.3	166.0 ± 6.4	<0.01
Mass (kg)	81.6 ± 12.1	69.0 ± 9.2	<0.01
Time in Military (years)	3.0 ± 2.3	3.0 ± 2.6	0.92
Time in MOS (years)	3.0 ± 2.1	2.8 ± 2.4	0.52
Number Deployed	54 (57%)	39 (42%)	–
Time Deployed (years) *for only those who have deployed*	0.9 ± 0.5	1.0 ± 0.8	0.62
Army Physical Fitness Test Score (points)	259.2 ± 27.5	255.8 ± 29.3	0.42
Push-ups (# / 2 min)	67.9 ± 12.0	40.9 ± 9.9	<0.01
Sit-ups (# / 2 min)	70.4 ± 11.6	68.0 ± 11.1	0.16
Two-Mile Run Time (min)	14.4 ± 1.4	17.1 ± 1.6	<0.01
Predicted VO_2max (ml/kg/min^{-1})	51.6 ± 5.5	47.3 ± 5.5	<0.01

Table 3.3. Raw Criterion Task Performance (19D)

		Foot March Time (min) [a]			Sandbag Carry Time (min) [a]			Move Under Fire Time (min) [a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		74.85	92.09	81.16	1.68	3.15	2.21	2.20	2.54	2.33
SD		6.54	13.59	12.77	0.26	1.28	1.07	0.13	0.22	0.23
Minimum		91.95	134.17	134.17	2.27	7.92	7.92	2.53	3.15	3.15
Percentiles	**5**	86.60	117.27	105.87	2.12	5.80	4.68	2.38	2.88	2.83
	10	85.88	108.35	98.63	2.05	5.23	3.42	2.37	2.85	2.65
	25	78.82	102.15	86.37	1.87	3.63	2.48	2.27	2.67	2.43
	50	73.88	89.98	77.93	1.65	2.73	1.88	2.20	2.52	2.28
	75	70.57	82.20	71.92	1.47	2.30	1.55	2.12	2.38	2.17
	90	68.28	76.00	69.08	1.35	2.03	1.42	2.08	2.30	2.10
	95	66.00	74.25	66.92	1.33	1.87	1.33	2.03	2.28	2.07
Maximum		56.58	71.52	56.58	1.08	1.60	1.08	1.57	2.07	1.57

		BFV Cas Evac Weight (lb)			Casualty Drag Speed (m/s)		
		M	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134
Mean		208	143	185	1.17	0.41	0.89
SD		7.00	33	38	0.29	0.32	0.47
Minimum		170	70	70	0.48	0.03	0.03
Percentiles	**5**	200	90	110	0.68	0.05	0.08
	10	210	100	120	0.82	0.06	0.17
	25	210	110	170	0.96	0.17	0.53
	50	210	140	210	1.21	0.39	0.96
	75	210	170	210	1.32	0.55	1.25
	90	210	190	210	1.56	0.77	1.42
	95	210	190	210	1.71	1.03	1.59
Maximum		210	210	210	1.96	1.55	1.96

M: Male; F: Female; C: Combined

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

Table 3.4. Criterion Task Performance Converted to Z-Scores (19D)

		Foot March Time (min) [a]			Sandbag Carry Time (min) [a]			Move Under Fire Time (min) [a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		0.44	-1.13	-0.13	0.50	-1.07	-0.08	0.48	-0.92	-0.03
SD		0.60	1.24	1.17	0.28	1.36	1.14	0.53	0.88	0.96
Minimum		-1.12	-4.98	-4.98	-0.13	-6.16	-6.16	-0.88	-3.41	-3.41
Percentiles	**5**	-0.63	-3.44	-2.39	0.03	-3.90	-2.71	-0.27	-2.32	-2.11
	10	-0.57	-2.62	-1.73	0.10	-3.30	-1.36	-0.20	-2.18	-1.36
	25	0.08	-2.05	-0.61	0.30	-1.59	-0.36	0.21	-1.43	-0.47
	50	0.53	-0.94	0.16	0.53	-0.63	0.29	0.48	-0.82	0.14
	75	0.84	-0.23	0.71	0.72	-0.17	0.63	0.82	-0.27	0.62
	90	1.04	0.34	0.97	0.85	0.12	0.78	0.96	0.07	0.89
	95	1.25	0.50	1.17	0.87	0.30	0.87	1.17	0.14	1.03
Maximum		2.12	0.75	2.12	1.13	0.58	1.13	3.08	1.03	3.08

		BFV Cas Evac Weight (lb)			Casualty Drag Speed (m/s)			Summed Z-Sum [a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		0.54	-1.17	-0.09	0.62	-1.05	0.01	2.58	-5.35	-0.32
SD		0.19	0.88	0.99	0.65	0.71	1.05	1.44	3.65	4.56
Minimum		-0.47	-3.10	-3.10	-0.89	-1.90	-1.90	-0.48	-15.79	-15.79
Percentiles	**5**	0.31	-2.57	-2.05	-0.45	-1.85	-1.79	0.15	-10.56	-9.26
	10	0.58	-2.31	-1.79	-0.14	-1.83	-1.58	0.50	-9.98	-7.89
	25	0.58	-2.05	-0.47	0.16	-1.59	-0.80	1.68	-7.99	-3.22
	50	0.58	-1.26	0.58	0.71	-1.10	0.15	2.57	-4.80	1.55
	75	0.58	-0.47	0.58	0.96	-0.75	0.81	3.55	-2.72	3.00
	90	0.58	0.05	0.58	1.49	-0.26	1.18	4.13	-0.69	3.92
	95	0.58	0.05	0.58	1.82	0.32	1.56	4.75	-0.58	4.39
Maximum		0.58	0.58	0.58	2.38	1.47	2.38	6.50	2.27	6.50

M: Male; F: Female; C: Combined

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

Table 3.5. Predictor Test Performance (19D)

		Beep Test Shuttles (#)			Medicine Ball Put (cm)			Illinois Agility Test (min) [a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		61	42	54	647.76	427.22	567.12	0.32	0.36	0.34
SD		17	11	18	88.17	53.07	131.50	0.02	0.03	0.03
Minimum		29	20	20	487.00	315.00	315.00	0.28	0.29	0.28
Percentiles	**5**	36	24	29	518.00	355.50	373.50	0.29	0.31	0.29
	10	42	26	34	528.00	366.00	396.00	0.30	0.32	0.30
	25	49	34	42	594.50	395.50	445.00	0.30	0.34	0.31
	50	60	42	52	635.00	422.00	580.25	0.32	0.37	0.33
	75	72	49	65	701.00	449.50	673.00	0.33	0.38	0.36
	90	77	58	75	754.50	521.00	736.00	0.35	0.40	0.38
	95	89	62	77	794.00	531.50	777.50	0.36	0.41	0.40
Maximum		147	67	147	927.00	539.50	927.00	0.42	0.42	0.42

		Upright Pull (lb)			Biceps Curl (lb)			Standing Long Jump (cm)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		338.50	196.56	286.60	102.64	58.40	86.46	209.60	160.50	191.70
SD		56.78	35.09	84.79	16.52	9.25	25.70	21.10	21.80	31.90
Minimum		209.15	123.50	123.50	72.00	40.25	40.25	168.5	115.0	115.0
Percentiles	**5**	249.00	135.10	150.00	79.70	46.00	47.85	181.0	125.0	131.5
	10	265.00	149.05	174.30	82.50	47.45	50.90	184.0	130.0	148.5
	25	298.40	173.80	212.50	89.80	50.80	64.25	194.0	147.5	169.0
	50	337.10	198.60	291.78	102.00	58.20	87.00	209.5	161.0	193.8
	75	380.40	223.20	351.20	111.70	66.00	105.85	222.5	175.0	215.0
	90	410.25	233.55	399.90	128.75	70.00	121.50	235.0	190.5	228.5
	95	418.25	255.15	414.65	130.95	71.55	130.00	245.0	196.0	238.5
Maximum		487.50	286.15	487.50	144.50	78.30	144.50	280.0	204.0	280.0

		Push-Ups (#)			Resistance Pull (m/s)			Powerball Throw (cm)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		51	32	44	0.81	0.17	0.58	582.10	295.50	477.30
SD		10	7	13	0.27	0.13	0.38	116.80	64.10	171.10
Minimum		26	14	14	0.12	0.00	0.00	258.00	166.50	166.50
Percentiles	**5**	35	18	24	0.31	0.02	0.05	407.50	204.50	227.50
	10	38	20	27	0.36	0.03	0.11	419.00	209.00	253.50
	25	46	27	35	0.68	0.10	0.18	501.00	252.00	324.50
	50	50	32	44	0.83	0.15	0.64	577.50	290.50	479.00
	75	56	38	52	1.02	0.20	0.93	662.50	345.00	620.00
	90	65	41	60	1.12	0.34	1.08	730.50	383.00	699.00
	95	68	41	66	1.17	0.43	1.14	770.00	392.00	739.50
Maximum		81	44	81	1.32	0.63	1.32	881.50	416.00	881.50

M: Male; F: Female; C: Combined

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

Table 3.5. Predictor Test Performance (19D) (continued)

		Sit-Ups (#)			Arm Ergometer (Rev / 2 min)			Handgrip Sum (lb)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134	85	49	134
Mean		48	46	47	255	191	232	210.84	133.08	182.41
SD		6	7	6	29	31	43	42.34	21.88	52.13
Minimum		31	31	31	185	104	104	106.95	92.90	92.90
Percentiles	**5**	39	34	37	201	150	155	137.85	99.50	105.90
	10	41	38	39	220	154	172	162.95	103.55	117.05
	25	44	41	43	235	170	201	181.30	117.05	137.85
	50	47	46	47	257	193	235	212.70	131.85	178.53
	75	51	51	51	275	210	266	235.05	150.60	220.30
	90	56	54	55	294	234	288	262.50	161.90	249.55
	95	58	58	58	299	241	295	277.25	169.75	267.05
Maximum		63	62	63	320	273	320	321.75	181.40	321.75

		300m Sprint (min) [a]			Squat Lift (lb)		
		M	**F**	**C**	**M**	**F**	**C**
n		85	49	134	85	49	134
Mean		0.89	1.04	0.94	215	154	193
SD		0.09	0.10	0.12	21	37	40
Minimum		0.71	0.88	0.71	60	100	60
Percentiles	**5**	0.76	0.89	0.77	180	100	120
	10	0.77	0.90	0.79	220	100	120
	25	0.81	0.97	0.86	220	120	160
	50	0.87	1.03	0.94	220	140	220
	75	0.96	1.10	1.03	220	180	220
	90	1.00	1.17	1.10	220	220	220
	95	1.05	1.20	1.17	220	220	220
Maximum		1.10	1.37	1.37	220	220	220

M: Male; F: Female; C: Combined

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

Table 3.6. Raw Criterion Task Performance (19K)

		Foot March Time (min) [a]			Move Under Fire Time (min) [a]			Abrams Cas Evac Weight (lb)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	92	187	95	92	187	95	92	187
Mean		78.17	89.56	83.78	2.20	2.59	2.39	207	148	178
SD		8.84	13.44	12.67	0.16	0.26	0.30	12	36	40
Minimum		107.05	138.80	138.80	2.62	3.42	3.42	140	80	80
Percentiles	**5**	93.47	108.83	104.28	2.47	3.03	2.94	190	90	110
	10	91.35	104.12	102.02	2.42	2.94	2.79	200	110	120
	25	82.30	99.42	91.65	2.32	2.74	2.59	210	120	140
	50	77.23	88.52	81.23	2.17	2.59	2.36	210	140	210
	75	71.55	78.99	74.92	2.06	2.44	2.16	210	180	210
	90	67.22	73.15	68.98	1.99	2.26	2.03	210	200	210
	95	66.88	71.12	67.08	1.96	2.17	1.99	210	210	210
Maximum		59.67	66.87	59.67	1.83	1.95	1.83	210	210	210

		Casualty Drag Speed (m/s)			Load the Main Gun (sec) [a]			Stow Ammo (rounds/min)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	92	187	95	92	187	94	92	184
Mean		1.15	0.46	0.81	16.63	24.30	20.40	7.62	3.38	5.52
SD		0.26	0.32	0.45	2.68	5.76	5.89	1.30	1.84	2.66
Minimum		0.59	0.02	0.02	27.36	44.09	44.09	5.33	0.00	0.00
Percentiles	**5**	0.73	0.05	0.10	21.57	36.88	31.95	5.63	0.20	0.73
	10	0.78	0.10	0.17	20.23	31.95	28.38	5.93	0.73	1.71
	25	1.00	0.18	0.45	17.79	27.06	22.90	6.84	2.02	3.58
	50	1.13	0.44	0.82	16.23	22.80	19.32	7.40	3.58	5.92
	75	1.31	0.71	1.14	14.98	20.57	16.03	8.44	4.53	7.52
	90	1.48	0.86	1.35	13.79	18.87	14.40	9.56	5.68	8.71
	95	1.61	1.03	1.48	12.92	17.21	13.65	10.09	6.24	9.56
Maximum		1.91	1.25	1.91	11.18	13.28	11.18	11.22	8.31	11.22

M: Male; F: Female; C: Combined

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

Table 3.7. Criterion Task Performance Converted to Z-Scores (19K)

		Foot March Time (min)[a]			Move Under Fire Time (min)[a]			Abrams Cas Evac Weight (lb)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	92	187	95	92	187	95	92	187
Mean		0.33	-0.64	-0.15	0.68	-0.91	-0.10	0.75	-0.77	0.00
SD		0.70	1.17	1.07	0.54	0.98	1.12	0.31	0.93	1.02
Minimum		-1.73	-5.15	-5.15	-0.80	-4.21	-4.21	-1.00	-2.98	-2.98
Percentiles	**5**	-0.84	-2.37	-2.07	-0.22	-2.62	-2.18	0.27	-2.31	-1.77
	10	-0.57	-2.07	-1.73	-0.09	-2.18	-1.65	0.63	-1.77	-1.51
	25	-0.07	-1.41	-0.75	0.28	-1.43	-0.94	0.79	-1.33	-0.92
	50	0.38	-0.57	0.10	0.76	-0.96	0.09	0.79	-0.88	0.79
	75	0.79	0.33	0.61	1.09	-0.16	0.76	0.87	-0.05	0.87
	90	1.17	0.71	1.04	1.31	0.29	1.18	0.87	0.63	0.87
	95	1.31	0.96	1.19	1.55	0.47	1.31	0.87	0.87	0.87
Maximum		1.87	1.32	1.87	1.82	1.30	1.82	0.87	0.87	0.87

		Casualty Drag Speed (m/s)			Load the Main Gun (sec)[a]			Stow Ammo (rounds/min)[a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	92	187	95	92	187	95	92	187
Mean		0.58	-1.01	-0.20	0.65	-0.63	0.02	0.78	-0.78	0.02
SD		0.63	0.78	1.06	0.46	0.97	0.99	0.48	0.67	0.97
Minimum		-1.01	-2.35	-2.35	-1.29	-3.59	-3.59	-0.05	-2.10	-2.10
Percentiles	**5**	-0.44	-2.22	-2.02	-0.13	-2.93	-1.77	0.04	-1.92	-1.73
	10	-0.13	-2.02	-1.80	0.13	-1.77	-1.27	0.19	-1.73	-1.28
	25	0.12	-1.49	-1.10	0.47	-1.02	-0.39	0.47	-1.18	-0.67
	50	0.57	-1.11	-0.02	0.67	-0.38	0.27	0.70	-0.68	0.19
	75	0.96	-0.44	0.58	1.01	-0.04	0.70	1.09	-0.35	0.73
	90	1.31	0.07	1.14	1.18	0.32	1.06	1.43	0.06	1.14
	95	1.79	0.23	1.31	1.28	0.62	1.18	1.83	0.25	1.43
Maximum		2.41	1.02	2.41	1.62	1.01	1.62	2.27	1.12	2.27

		Summed Z-Score [a]		
		M	**F**	**C**
n		95	92	187
Mean		3.80	-4.71	-0.39
SD		2.03	4.21	5.38
Minimum		-2.01	-14.39	-14.39
Percentiles	**5**	0.55	-12.76	-9.76
	10	1.52	-9.76	-8.07
	25	2.49	-7.59	-4.59
	50	3.90	-4.68	1.37
	75	4.96	-1.89	3.96
	90	6.31	0.87	5.47
	95	7.15	2.31	6.31
Maximum		8.88	5.95	8.88

M: Male; F: Female; C: Combined

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

Table 3.8. Predictor Test Performance (19K)

		Beep Test Shuttles (#)			Medicine Ball Put (cm)			Illinois Agility Test (min)[a]		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	90	185	95	91	186	95	91	186
Mean		73	45	60	611.15	417.34	516.33	0.30	0.34	0.32
SD		17	13	21	88.99	59.56	123.23	0.02	0.03	0.03
Minimum		38	17	17	465.0	302.0	302.0	0.26	0.29	0.26
Percentiles	**5**	49	24	30	479.0	334.5	347.0	0.27	0.30	0.28
	10	53	29	35	501.5	347.0	366.0	0.28	0.31	0.28
	25	62	37	42	543.0	371.0	412.0	0.29	0.32	0.30
	50	73	43	56	605.0	409.5	504.5	0.30	0.34	0.32
	75	85	53	73	674.0	457.5	610.5	0.31	0.36	0.34
	90	96	64	89	718.0	500.0	692.5	0.33	0.38	0.37
	95	98	69	96	790.0	526.5	718.0	0.35	0.39	0.38
Maximum		112	74	112	852.5	577.0	852.5	0.41	0.40	0.41

		Upright Pull (lb)			Biceps Curl (lb)			Push-Ups (#)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	90	185	95	90	185	95	90	185
Mean		308.61	198.49	255.04	96.91	60.62	79.26	49	30	40
SD		51.81	36.33	71.11	18.82	11.34	23.96	11	9	14
Minimum		172.90	131.05	131.05	51.25	33.60	33.60	26	16	16
Percentiles	**5**	226.35	143.10	152.60	69.80	40.65	45.35	33	17	18
	10	241.45	152.50	161.60	74.25	45.10	51.75	36	18	23
	25	274.30	167.75	194.80	84.35	53.15	60.35	41	25	30
	50	308.75	195.48	247.30	93.50	60.23	75.55	48	31	39
	75	351.55	228.00	308.75	111.00	67.65	93.95	56	37	49
	90	371.90	246.58	354.05	122.30	74.90	113.35	65	45	60
	95	393.35	263.45	371.90	126.95	79.65	122.30	70	48	65
Maximum		452.50	274.30	452.50	154.30	91.75	154.30	74	50	74

		Standing Long Jump (cm)			Resistance Pull (m/s)			Powerball Throw (cm)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	91	186	95	90	185	95	90	185
Mean		208.8	160.8	185.3	0.77	0.25	0.52	630.3	367.2	502.3
SD		28.0	21.1	34.6	0.33	0.20	0.38	126.1	90.9	171.7
Minimum		143.0	118.5	118.5	0.01	0.01	0.01	329.0	188.5	188.5
Percentiles	**5**	167.5	128.0	131.5	0.02	0.02	0.02	426.5	222.5	266.0
	10	175.5	131.5	141.0	0.21	0.06	0.07	470.0	266.0	299.5
	25	187.5	143.5	159.0	0.58	0.10	0.16	541.0	311.0	351.5
	50	206.5	160.0	183.0	0.80	0.18	0.49	627.0	350.8	489.5
	75	230.5	175.5	208.0	0.97	0.36	0.84	694.5	415.5	641.0
	90	246.0	188.5	235.0	1.17	0.53	1.05	803.5	475.0	734.5
	95	256.5	198.5	246.0	1.26	0.67	1.17	850.0	548.0	803.5
Maximum		284.0	202.5	284.0	1.35	0.83	1.35	999.0	665.0	999.0

M: Male; F: Female; C: Combined

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

Table 3.8. Predictor Test Performance (19K) (continued)

		Sit-Ups (#)			Arm Ergometer (Rev / 2 min)			Handgrip Sum (lb)		
		M	**F**	**C**	**M**	**F**	**C**	**M**	**F**	**C**
n		95	140	185	95	91	186	95	91	186
Mean		47	45	46	280.10	210.20	245.90	208.55	134.43	172.29
SD		6	6	6	30.60	36.80	48.60	39.16	27.54	50.28
Minimum		35	34	34	184	129	129	127.40	75.45	75.45
Percentiles	**5**	38	35	36	229	148	162	148.40	92.00	97.80
	10	40	37	38	240	162	184	157.90	97.80	110.55
	25	43	40	41	260	190	209	182.60	115.45	134.70
	50	46	45	46	284	209	251	207.85	134.70	167.90
	75	51	50	50	300	234	285	230.85	153.40	207.95
	90	55	53	53	318	260	304	249.20	171.65	243.20
	95	60	56	57	324	278	318	269.40	176.70	249.20
Maximum		66	59	66	357	290	357	354.00	207.30	354.00

		300m Sprint (min)[a]			Squat Lift (lb)		
		M	**F**	**C**	**M**	**F**	**C**
n		94	90	184	94	90	184
Mean		0.85	1.08	0.96	216	161	189
SD		0.08	0.11	0.15	14	37	39
Minimum		0.70	0.83	0.70	120	80	80
Percentiles	**5**	0.74	0.91	0.75	200	100	120
	10	0.75	0.93	0.78	220	120	120
	25	0.78	1.00	0.83	220	140	160
	50	0.84	1.07	0.94	220	160	220
	75	0.92	1.13	1.07	220	180	220
	90	0.96	1.22	1.15	220	220	220
	95	1.00	1.25	1.21	220	220	220
Maximum		1.02	1.46	1.46	220	220	220

M: Male; F: Female; C: Combined

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

Table 3.9. Correlations amongst Criterion Tasks and Predictor Tests (19D)

	Foot March	Sandbag Carry	Move Under Fire	BFV Cas Evac	Casualty Drag
Beep Test	-0.53**	-0.44**	-0.55**	0.46**	0.42**
Med Ball Put	-0.65**	-0.68**	-0.65**	0.79**	0.80**
Illinois Agility	0.50**	0.55**	0.65**	-0.62**	-0.53**
Upright Pull	-0.63**	-0.66**	-0.66**	0.76**	0.80**
Biceps Curl	-0.64**	-0.67**	-0.65**	0.78**	0.79**
SLJ[1]	-0.58**	-0.65**	-0.71**	0.71**	0.71**
Push-Up	-0.57**	-0.50**	-0.60**	0.61**	0.57**
Resistance Pull	-0.65**	-0.67**	-0.63**	0.78**	0.84**
Powerball Throw	-0.66**	-0.66**	-0.64**	0.79**	0.84**
Sit-Up	-0.14	0.02	-0.21*	0.09	0.15
Arm Ergometer	-0.61**	-0.67**	-0.67**	0.72**	0.67**
Handgrip (sum)	-0.62**	-0.62**	-0.56**	0.68**	0.73**
300m Sprint	0.57**	0.55**	0.66**	-0.58**	-0.56**
Squat Lift	-0.62**	-0.73**	-0.65**	0.80**	0.70**

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

Table 3.10. Regression Results of Full Predictive Models: Unstandardized Coefficients (19D)

Tests Excluded from Model	**Best 6-Predictor**		**6-Predictor No Arm Ergometer** *Arm Ergometer*		**No Calibrated Equipment (4)** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl*		**Stopwatch & Tape Measure Only (5)** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl, Medicine Ball Put, Powerball Throw, Squat Lift*		**Stopwatch & Tape Measure Only (4)** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl, Medicine Ball Put, Powerball Throw, Squat Lift*	
	ß	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**
Constant	-21.728**	1.418**	-18.787**	1.739**	-23.393**	1.013**	-7.015	4.594	-15.530**	1.966**
Squat Lift	0.033**	0.006**	0.035**	0.006**	0.040**	0.006**				
SLJ[1]	0.034**	0.008**	0.034**	0.008**	0.033**	0.008**	0.069**	0.010**	0.078**	0.010**
Beep Test	0.045**	0.010**	0.050**	0.010**	0.043**	0.010**	0.046**	0.015**	0.056**	0.015**
Med Ball Put	0.01**	0.002**	0.008**	0.003**	0.012**	0.006**				
1-Minute Sit-up	-0.065*	0.026*	-0.066*	0.026*			-0.141**	0.038**	-0.150**	0.038**
AE[2]	0.015*	0.006*								
Resist. Pull			1.899	0.990						
1-Minute Push-Up							0.089**	0.024**	0.094**	0.024**
Illinois Agility							-18.981*	9.282*		
R-squared	**0.86**		**0.85**		**0.84**		**0.71**		**0.70**	
Adj. R-squared	**0.85**		**0.85**		**0.84**		**0.70**		**0.69**	
Std. Error of Measurement	**1.765**		**1.782**		**1.841**		**2.505**		**2.536**	

n=134; * 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] Standing Long Jump
[2] 2-Minute Arm Ergometer

Table 3.11. Regression Results of Predictive Models: Predictive Capabilities (19D)

		All Tests Combined	Individual Test r				
		Full Model Adj. R^2	Foot March	Sandbag Carry	Move Under Fire	BFV Cas Evac	Cas Drag
Best 6-Predictor	Squat Lift + SLJ[1] + Beep Test + Med Ball Put + 1-Min Sit-up + AE[2]	**0.85**	0.74	0.81	0.80	0.88	0.83
6-Predictor No Arm Ergometer	Squat Lift + Resistance Pull + SLJ[1] + Beep Test + Med Ball Put + 1-Min Sit-up	**0.85**	0.74	0.81	0.78	0.88	0.86
Best 4-Predictor = No Calibrated Equipment	Squat Lift + SLJ[1] + Beep Test + Med Ball Put	**0.84**	0.74	0.78	0.78	0.87	0.83
5 Predictor Stopwatch & Tape Measure Only	SLJ[1] + Beep Test + 1-Min Sit-up + 1-Min Push-up + Illinois Agility	**0.70**	0.68	0.73	0.78	0.78	0.73
4 Predictor Stopwatch & Tape Measure Only	SLJ[1] + Beep Test + 1-Min Sit-up + 1-Min Push-up	**0.69**	0.68	0.72	0.76	0.77	0.73

[1]Standing Long Jump

[2]2-Minute Arm Ergometer

Table 3.12. Correlations amongst Criterion Tasks and Predictor Tests (19K)

	Foot March	Move Under Fire	Abrams Cas Evac	Casualty Drag	Load Main Gun	Stow Ammo
Beep Test	-0.47**	-0.69**	0.58**	0.56**	-0.53**	0.65**
Medicine Ball Put	-0.50**	-0.69**	0.73**	0.83**	-0.68**	0.79**
Illinois Agility	0.43**	0.72**	-0.59**	-0.63**	0.61**	-0.65**
Upright Pull	-0.49**	-0.58**	0.75**	0.85**	-0.67**	0.79**
Biceps Curl	-0.40**	-0.57**	0.70**	0.79**	-0.64**	0.76**
SLJ[1]	-0.39**	-0.72**	0.65**	0.73**	-0.58**	0.69**
Push-Up	0.47**	-0.73**	0.62**	0.61**	-0.59**	0.68**
Resistance Pull	-0.50**	-0.55**	0.66**	0.77**	-0.64**	0.73**
Powerball Throw	-0.52**	-0.61**	0.74**	0.86**	-0.69**	0.82**
Sit-Up	-0.24**	-0.36**	0.28**	0.20**	0.22**	0.22**
Arm Ergometer	-0.59**	-0.62**	0.70**	0.72**	-0.72**	0.80**
Handgrip (sum)	-0.51**	-0.58**	0.71**	0.80**	-0.68**	0.75**
300m Sprint	0.50**	-0.67**	-0.67**	-0.73**	0.66**	-0.73**
Squat Lift	-0.50**	-0.53**	0.77**	0.81**	-0.68**	0.74**

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

Table 3.13. Regression Results of Full Predictive Models: Unstandardized Coefficients (19K)

Tasks Excluded from Model	**Best 5-Predictor**		**Best 4-Predictor**		**5-Predictor No Calibrated Equipment** *Arm Ergometer, Handgrip, Upright Pull, Biceps Curl*		**4-Predictor 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, Powerball Throw, Squat Lift*	
	ß	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**	**ß**	**Std. Error**
Constant	-11.227**	3.223**	-7.637*	2.957*	-14.861**	2.890**	-13.493**	3.042**	11.042	6.170
Med Ball Put	0.012**	0.002**	0.012**	0.002**	0.011**	0.003**	0.016**	0.002**		
AE[1]	0.036**	0.005**	0.040**	0.005**						
Illinois Agility	-34.104**	7.481**	-43.182**	6.716**					-33.807**	11.624**
Squat Lift	0.028**	0.006**	0.028**	0.006**	0.03**	0.007**	0.036**	0.007**		
Beep Test	0.029**	0.11**								
300m Sprint					-3.222	1.930	-5.966**	1.947**	-10.884**	2.342**
Push-Up					0.117**	0.019**	0.092**	0.019**	0.100**	0.024**
Resist. Pull					3.341**	0.707**				
SLJ[2]									0.032**	0.011**
R-squared	**0.86**		**0.85**		**0.83**		**0.81**		**0.71**	
Adj. R-squared	**0.85**		**0.85**		**0.82**		**0.80**		**0.71**	
Std. Error of Measurement	**2.067**		**2.100**		**2.267**		**2.399**		**2.922**	

n=184; * 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-Minute Arm Ergometer
[2]Standing Long Jump

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Table 3.14. Regression Results of Predictive Models: Predictive Capabilities (19K)

		All Tests Combined	Individual Test r					
		Full Model Adj. R^2	Foot March	Move Under Fire	Abrams Cas Evac	Cas Drag	Load Main Gun	Stow Ammo
Best 5-Predictor	Med Ball Put + AE[1] + Illinois Agility + Squat Lift + Beep Test	**0.86**	0.63	0.81	0.84	0.89	0.80	0.89
Best 4-Predictor	Med Ball Put + AE[1] + Illinois Agility + Squat Lift	**0.85**	0.63	0.79	0.84	0.89	0.80	0.89
5-Predictor No Arm Ergometer = 5-Predictor No Calibrated Equipment	Med Ball Put + 300m Sprint + Squat Lift + 1-Min Push-up + Resist. Pull	**0.83**	0.59	0.80	0.84	0.90	0.77	0.87
4-Predictor No Arm Ergometer = 4-Predictor No Calibrated Equipment	Med Ball Put + 300m Sprint + Squat Lift + 1-Min Push-up	**0.81**	0.57	0.79	0.83	0.89	0.76	0.85
Stopwatch & Tape Measure Only	300m Sprint + Illinois Agility + 1-Min Push-up + SLJ[2]	**0.71**	0.54	0.82	0.73	0.79	0.70	0.79

[1]2-Minute Arm Ergometer

[2]Standing Long Jump

Table 3.15. 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 Weight Load Carry	Weight Load Carry	Fire and Movement
	Canada (6, 9)		Sandbag Drag	Sandbag Lift Intermittent Loaded Sandbags	Sandbag Lift Intermittent Loaded Sandbags	20m Rushes
	United Kingdom (5, 27, 28)	Static Lift		Jerry Can Carry 2-Minute Push-Ups 2-Minute Sit-Ups	1.5-Mile Run	
Proposed 19 D Test Batteries	**Best 6-Predictor**	Squat Lift	Med Ball Put SLJ[1]	2-Min AE[2] 1-Min Sit-up	Beep Test	
	6-Predictor No Arm Ergometer	Squat Lift	Resistance Pull Med Ball Put SLJ[1]	1-Min Sit-up	Beep Test	
	Best 4-Predictor = No Calibrated Equipment	Squat Lift	Med Ball Put SLJ[1]		Beep Test	
	5 Predictor Stopwatch & Tape Measure		SLJ[1]	1-Min Push-up 1-Min Sit-up	Beep Test	Illinois Agility
	4 Predictor Stopwatch & Tape Measure		SLJ[1]	1-Min Push-up 1-Min Sit-up	Beep Test	
Proposed 19K Test Batteries	**Best 5-Predictor**	Squat Lift	Med Ball Put	2-Min AE[2]	Beep Test	Illinois Agility
	Best 4-Predictor	Squat Lift	Med Ball Put	2-Min AE[2]		Illinois Agility
	5-Predictor No Arm Ergometer = 5-Predictor No Calibrated Equipment	Squat Lift	Med Ball Put 300m Sprint Resist. Pull	1-Min Push-up		
	4-Predictor No Arm Ergometer = 4-Predictor No Calibrated Equipment	Squat Lift	Med Ball Put 300m Sprint	1-Min Push-up		
	Stopwatch & Tape Measure		300m Sprint SLJ[2]	1-Min Push-up		Illinois Agility

[1]Standing Long Jump
[2]Arm Ergometer

Figure 3.1. Schematic of the Illinois Agility Test

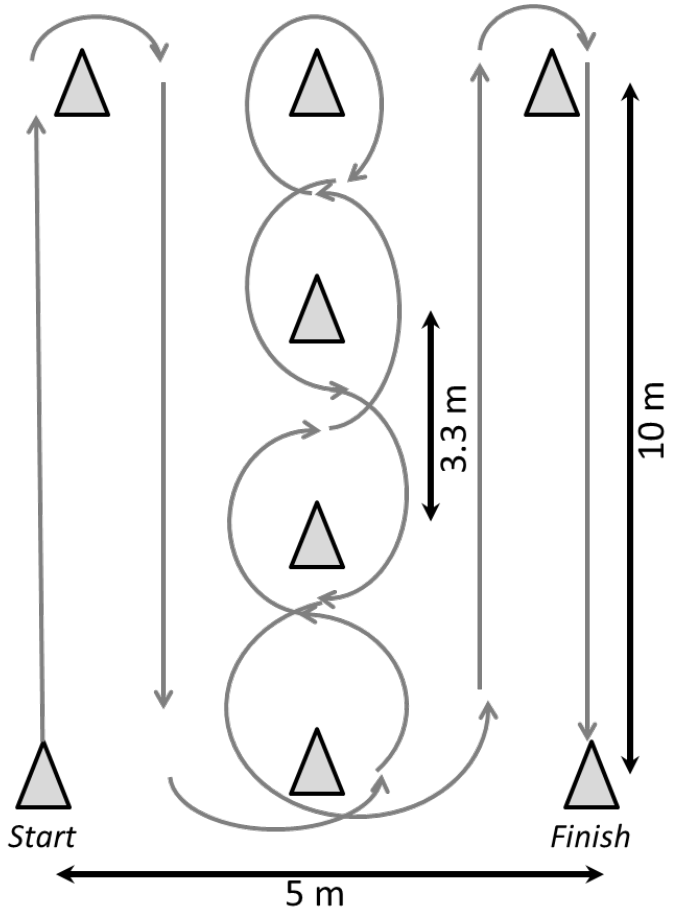

Figure 3.2. Image of Arm Ergometer Test

CONCLUSIONS

This set of three studies used best practices set out by Payne and Harvey to develop a physical testing battery for Armor. Study 1 identified the most physical demanding tasks. Of the physically demanding tasks listed by SMEs for each MOS, five 19D tasks and six 19K tasks were identified as capturing the physical demands of the MOS. For the 19D, the foot march captured load carriage; BFV casualty evacuation captured heavy lifting; sandbag carry captured repeated lifting and carrying, and the casualty drag captured heavy drags, and the move under fire captured agility. For the 19K, the foot march captured load carriage; Abrams casualty evacuation and loading the main gun captured two distinct aspects of heavy lifting; stow ammo on an Abrams tank captured repeated lifting and carrying, and the casualty drag captured heavy drags, and the move under fire captured agility. Following approval of the task selection by SMEs, task simulations were developed and reliability of the tasks was determined in Study 2. Finally, five models, using different sets of predictor tests, were developed for each MOS in Study 3.

The five models for 19D were (from best to worst predictive ability):

- squat lift, standing long jump, beep test, medicine ball put, 1-minute sit-up, and arm ergometer
- squat lift, standing long jump, beep test, medicine ball put, and resistance pull
- squat lift, standing long jump, beep test, medicine ball put
- standing long jump, beep test, 1-minute sit-up, 1-minute push-up, Illinois agility
- standing long jump, beep test, 1-minute sit-up, 1-minute push-up

The five models for 19K were (from best to worst predictive ability):

- medicine ball put, arm ergometer, Illinois agility, squat lift, and beep test
- medicine ball put, arm ergometer, Illinois agility, squat lift
- medicine ball put, 300m sprint, squat lift, 1-minute push-up, resistance pull
- medicine ball put, 300m sprint, squat lift, 1-minute push-up
- 300m sprint, Illinois agility, 1-minute push-up, standing long jump

The models presented herein are developed specifically using information from the Armor studies. Additional studies were conducted using Soldiers from the Combat Engineers (12B), Field Artillery (13B, 13F), and Infantry (11B, 11C). When these studies are compiled, one overarching test battery of five to seven tests to cover all seven Combat Arms MOSs will need to be developed in order to complete the tasking from TRADOC. While this final model may not be optimized for any one MOS, it will provide a testing battery able to identify candidates for each of the seven Combat Arms MOSs.

RECOMMENDATIONS

- The Armor MOSs 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 Armor Soldiers should be considered. If a new task is identified with greater 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. LIST OF PARTICIPANTS ON REVIEW PANEL FOR DEVELOPING TASK STANDARDS FOR ARMOR SOLDIERS

Armor School Senior Reviewers

COL Paul Laughlin, Chief of Armor / Armor School Commandant
CSM Miles Wilson, Armor School CSM
COL Scott King, Deputy Commandant
COL David Davidson, Commander, 316th Cavalry Brigade
CSM Michael Clemons, 316th Brigade CSM
COL Kevin MacWatters, Commander, 194th Armor Brigade
CSM Robert Tompkins, 194th Brigade CSM
LTC Dominick Edwards, Strategic Initiatives
MAJ(P) Joseph Jasper, Strategic Initiatives

Branch Review Panel

LTG Mark Hertling, CG, USAREUR
BG Michael Bills, USAREUR G-3
BG James Pasquerrette, Director, Programs and Analysis, HQDA G-8
COL Patrick Matlock, Commander, 170th Infantry Brigade
COL Ed Bohnemann, Commander, 172nd Infantry Brigade
COL Keith Barclay, Commander, Stryker Cavalry Regiment
COL Joe Wawro, Commander 4th Bde, 4th ID
COL Johnny Richardson, Commander3 Cavalry Regiment

Office, Chief of Armor (OCOA) Proponency SMEs:

GS-14 (CSM Ret) George DeSario, Director OCOA
CPT Branden Jefferson, Officer Career Manager
SGM (Fmr Bn CSM) Gregory Proft, OCOA SGM
SFC David Neuzil, 19D Career Manager
SFC Jason Hansford, 19Z Career Manager
SFC William Galloway, ARNG Senior Sergeant

APPENDIX B. 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 C. 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
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 Horizontal Distance: 24 km Vertical Distance: Terrain Dependant 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) 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 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
Throw hand grenade to engage enemy forces

Weight: 1 lb Horizontal Distance: 30 m Vertical Distance: N/A Time: N/A	Weight: M67 Fragmentation Grenade or M69 Practice Hand Grenade Horizontal Distance: Doctrinally, the Army considers 30 m to be hand grenade range, 30 m engages a 35 m target

*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 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 **Dig, lift, and shovel 11 lbs scoops of dirt in bent, stooped or kneeling position into sandbags.**	
Weight: 11 lbs Horizontal Distance: N/A Vertical Distance: 0.75 m Time: 52 minutes	Weight: 11 lbs is combined weight of e-tool and average weight of various soil compositions Vertical Distance: 0.75 meters is height of a sandbag, 3-5 scoops of dirt fill one sandbag One hasty fighting position (without overhead cover) uses 26 sand bags 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 **Lift 30-40 lb sandbags waist to shoulder high, carry them 10 m and emplace**	
Weight: 30-40 lbs Horizontal Distance: 10 m Vertical Distance: 1 m to 1.5 m Time: 26 minutes	Weight: Based on soil composition and bags filled 55-60%, a sandbag weighs 30-40 lbs Horizontal Distance: 10 meters is farthest distance carried from fill point without a vehicle Vertical Distance: Waist to shoulder height 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 **Individually lift, drag, and carry a casualty to a safe location; casualty is in harm's way**	
Weight: ~271 lbs Horizontal Distance: 15 m Vertical Distance: 0.5-2 m Time: As quickly as possible	Weight: ~188 lbs incapacitated Soldier with an 83 lb Fighting Load Horizontal Distance: 15m is approximately half the distance a Soldier could move during a 3-5 second rush 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 **Three Soldiers perform this task from a BFV, Stryker, or Buffalo**	
Weight: ~207 lbs (prorated ~103.5 ls) Horizontal Distance: 1-2 m Vertical Distance: 1.5 m Time: 2 Minutes	Weight: ~188 lbs incapacitated Soldier with 19 lbs of Vehicle Crewman Uniform and equipment Horizontal Distance: 1.5 m is the height from the commander's seat to the top of the turret 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) Horizontal Distance: 3 m or 25 m Vertical Distance: 1 m Time: n/a	Weight: Barrel weighs 107 lbs Horizontal Distance: Barrel to BFV 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 Horizontal Distance: 1 m Vertical distance: 6 in 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 Horizontal Distance: 15 m Vertical distance: 1 m Time: N/A	Weight: One 25mm ammunition can weighs 45 lbs (contains 45 rounds) Basic Load (25mm) for a BFV is 900 rounds (30 ammunition cans) Horizontal Distance: 15 m is an estimated safe distance between the back of the BFV and the ammunition supply point or ammunition carrier 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 8: Load the TOW Missile Launcher on BFV 11B, 19D

Task: Load TOW-2B Aero (BGM-71F6) Missile into a BFV Mounted TOW Weapon System

Condition: Wearing / Carrying 64–80* lb Fighting Load(-) (no weapon) and given a BFV with a TOW Missile Launcher and 2 TOW-2B Aero (BGM-71F6) Missiles

Standard: 2 Missiles properly loaded

Lift 65 Pounds 1 Meter and Carry 2 Meters	
Weight: 65 lbs Horizontal Distance: 2 m Vertical Distance: 1 m Time: N/A	Weight: TOW-2B Missile weighs 65 lbs Vertical Distance: Rear of launcher lowers to ~1 m from floor of crew compartment

*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 17: Mount M2 .50 Cal Machine Gun Receiver on an Abrams Tank 19K

Task: Mount M2 .50 Caliber Machine Gun Receiver on an M1 Abrams Tank

Condition: Wearing / Carrying 30-44* lbs (IOTVC with ESAPI and ESBI, CVC/ACH Helmet) and given an Abrams Tank and an M2 .50 Caliber Machine Gun Receiver located next to the tank

Standard: M2 .50 Caliber Machine Gun Receiver properly mounted

Lift 56 Pounds 1.2 Meters, Carry 2.4 Meters, and Put on a Mount	
Weight: 56 lbs Horizontal Distance: 1.2 m Vertical Distance: 2.4 m (2 x 1.2 m) Time: n/a	Weight: M2 .50 Caliber Machine Gun Receiver weighs 56 lbs Vertical Distance: Ground to turret (ground to hull, hull to turret) Horizontal Distance: Distance to mount

V1, 5 Sep 2013

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

Task 18: Stow Ammunition on an Abrams Tank (Variation 1 (Preferred)) 19K

Task: Move 120mm MPAT Rounds from Ammo Pad or HEMTT to Tank; 2 Soldier Task (1 on Ammo Pad or HEMTT, 1 in Tank)

Condition: Wearing / Carrying 63.65 to 78.19** lbs Fighting Load(no weapon) and given an Abrams Tank and 36 120mm MPAT Rounds on an Ammo Pad or HEMTT directly adjacent to the Tank

Standard: Load 36 MPAT Rounds from Ammo Pad or HEMTT to Ready Rack in 20 minutes (Parts 1 and 2)

Lift 55 Pounds 1 Meter and Carry .5 Meters (Part 1)	
Weight: 55 lbs Horizontal Distance: 0.5 m Vertical Distance: 1 m Time: 20 min (Part 1 and Part 2)	Weight: 120mm MPAT round weighs 55 lbs Horizontal Distance: Ammo Pad or HEMTT to tank Vertical Distance: Approximate height at which round is carried Time: Loading 36 rounds takes 20 minutes

Lift 55 Pounds 1.2 Meters and Carry .5 Meter (Part 2)	
Weight: 55 lbs Horizontal Distance: 0.5 m Vertical Distance: 1.2 m Time: 20 min (Part 1 and Part 2)	Weight: 120mm MPAT round weighs 55 lbs Horizontal Distance: Ammo pad or HEMTT to hull, hull to turret, turret to internal ready rack Vertical Distance: Turret to internal ready rack Time: Loading 36 rounds takes 20 minutes

*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 18: Stow Ammunition on an Abrams Tank (Variation 2) 19K

Task: Move 120mm MPAT Rounds from Ammo Point to Tank; 3 Soldier Task (1 on Ground, 1 on Hull, 1 in Turret)

Condition: Wearing / Carrying 63.65 to 78.19** lbs Fighting Load(no weapon) and given an Abrams Tank and 36 120mm MPAT Rounds 5 meters from Abrams Tank

Standard: Load 36 MPAT Rounds from Ammo Point to Ready Rack in 20 minutes (Parts 1 and 2)

Lift 55 Pounds 1 Meter and Carry 5 Meters (Part 1)	
Weight: 55 lbs Horizontal Distance: 5 m Vertical Distance: 1 m Time: 20 min (Inclusive of both Part 1 and Part 2)	Weight: 120mm MPAT tank round weighs 55 lbs Horizontal Distance: Ammo point to tank - Hands 120mm round to Soldier on hull Vertical Distance: Approximate height at which the round is carried Time: Loading 36 rounds takes 20 minutes

Lift 55 Pounds 1.2 Meters and Carry .5 Meter (Part 2)	
Weight: 55 lbs Horizontal Distance: 0.5 m Vertical Distance: 1.2 m Time: 20 min (Inclusive of both Part 1 and Part 2)	Weight: 120mm MPAT round weighs 55 lbs Horizontal Distance: Hull to turret, turret to internal ready rack Vertical Distance: Hull to turret; turret to internal ready rack Time: Loading 36 rounds takes 20 minutes.

*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 19: Load the 120mm Main Gun 19K

Task: Load a 120mm MPAT Round from the Ready Rack into the Breach

Condition: Wearing / 30-44* lbs (IOTVC with ESAPI and ESBI, CVC/ACH Helmet) and given 5 120mm MPAT rounds, M1 Abrams Tank

Standard: Successfully load 5 120mm MPAT Rounds in 35 seconds; one round every 7 seconds

Lift 55 Pounds 1 Meter and Rotate 1 Meter	
Weight: 55 lbs Horizontal Distance: 1 m Vertical Distance: 1 m Time: 7 seconds per round; 35 seconds total	Weight: 120mm MPAT round weighs 55 lbs Horizontal Distance: Ready rack to breach - Motion is a rotational, twisting movement to load round into the breech Vertical Distance: Ready rack to breach Time: 1 round is loaded every 7 seconds during gunnery Firing Mission: 5 Rounds

V1, 5 Sep 2013

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

Task 20: Remove a Casualty from an Abrams Tank (Mounted) 19K

Task: Remove a Casualty from an Abrams Tank (through Gunner's or Commander's Hatch); 3 Soldier Task

Condition: Wearing / Carrying 30-44* lb Fighting Load(-) (no weapon, no helmet, no fighting load carrier) and given a casualty (~188 lbs) with a 30-44* lb Fighting Load(-) (no weapon, no helmet, no fighting load carrier) for a total weight of ~218-232* and an Abrams Tank

Standard: Casualty removed from Abrams Tank

Lift from the Inside of a Tank Turret Three Soldiers perform this task from an Abrams Tank	
Weight: ~218-232* lbs (prorated ~73-77 lbs) Horizontal Distance: 1-2 m Vertical Distance: 1.5 m Time: As quickly as possible	Weight: ~188 lb incapacitated Soldier with 30-44* lb Fighting Load(-) Horizontal Distance: 1.5 m is the height from the commander's seat to the top of the turret Vertical Distance: To clear vehicle

V1, 5 Sep 2013

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

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

	06-07FEB, 10 FEB Week 1	11-12FEB, 21 FEB Week 2	24-26 FEB Week 3	28 FEB, 03-04 MAR Week 4	05-07 MAR Task Review
19K	Introduction to Armor Tasks	Gain proficiency of Armor Tasks	Mastery of assigned Armor Tasks	Culminating Exercise/Validation of Armor Tasks	Armor Test Preparation and Review
	(Welcome and Task Overview)	(Leadership Reaction Course)	(8-Mile Ruck)	(Obstacle Course)	(Squad Competition)
19D	Introduction to Cavalry Scout Tasks	Gain proficiency of Cavalry Scout Tasks	Mastery of assigned Cavalry Scout Tasks	Culminating Exercise/Validation of Cavalry Scout Tasks	Cavalry Scout Test Preparation and Review
	(Welcome and Task Overview)	(Leadership Reaction Course)	(8-Mile Ruck)	(Obstacle Course)	(Squad Competition and CCTT)

From 1-30 IN BN

APPENDIX E. MINUTES OF THE ARMOR SUBJECT MATTER EXPERT BRIEFING FOR APPROVAL OF CRITERION TASKS

19D and 19K SME VTC
10/9/2014

Soldiers present
TRADOC G3/5/7
MAJ Richard Jones and Mr. Jack Myers

Office of the Chief of Armor (OCOA):
SGM Gregory Proft, SFC Jason Hansford, Mr. George DeSario

USARIEM Personnel:
Mrs. Marilyn Sharp, MAJ Bradley Warr, Dr. Jan Redmond, Dr. Stephen Foulis, and Mrs. Leila Walker

MAJ Jones stated the purpose of the meeting was to brief OCOA SMEs on the Armor task simulations and obtain the approval of the Armor Commandant. This was done in an effort to provide understanding, allow for additional input from the SMEs, and obtain support and approval from the SMEs. This information would ultimately be communicated to the Armor Commandant, as a request for a Memorandum for Record declaring support from the Armor Branch, in order for USARIEM to continue the planned research

The final outcome of the Physical Demands Study will be to provide a battery of physical predictor tests to identify recruits who have the physical potential to succeed as Armor Soldiers (19D/19K). The progress to date included the identification of the critical tasks and standards for these MOSs (OCOA in coordination with TRADOC), the verification of the tasks and standards (TRADOC), the conduct of Focus groups, and the measurement of the physiological demands of the tasks identified (USARIEM).

The following tasks were identified for the 19D MOS: Conduct a Tactical Movement; Employ a Hand Grenade; Prepare a Fighting Position (Fill and Emplace Sandbags); Drag a Casualty to Immediate Safety (Dismounted); Lift, Carry, and Install the Barrel of a 25mm gun on the Bradley Fighting Vehicle (BFV); Remove the Feeder Assembly of a 25mm gun on the BFV; Load 25mm HEI-T Ammunition Cans onto the BFV; and Load TOW Missile Launcher on BFV.

The following tasks were identified for the 19K MOS: Employ a Hand Grenade; Prepare a Fighting Position (Fill and Emplace Sandbags); Drag a Casualty to Immediate Safety (Dismounted); Remove a Casualty from a Vehicle (Mounted); Mount M2 .50 Caliber Machine Gun on Abrams Tank; Stow Ammunition on an Abrams Tank; Load the 120mm Main Gun on an Abrams Tank; and Remove a Casualty from and Abrams Tank.

It should be noted that USARIEM determined the hand grenade (19D/19K) was primarily skill based, rather than physically demanding, so this tasks were not considered in our analysis.

USARIEM measured the physical effort of Soldiers performing the tasks (19D: 23 men and 15 women, 19K: 23 men and 15 women). Measurements included timing, pacing, ratings of perceived effort, heart rate and physiological energy cost.

USARIEM initiated the task simulation process, but needed the input from SMEs to ensure the task simulations are representative of the real tasks, to ensure the most important tasks were represented and to set an entry level of performance on each of the simulations (i.e., time to completion, speed of movement, etc.).

There were a number of important considerations in the development of the task simulations:

a. Test individual physical capabilities
b. Allow for a range of scores to show differences between people- cannot be go/no-go.
c. Measure unique physical capabilities.
d. Tests must not endanger Soldiers.
e. Require minimal, readily available equipment.
f. Be reliable (same person gets same score on different days).
g. Require minimal skill and practice.
h. Be time efficient.

The tasks for each MOS were grouped into categories. OCOA representatives concurred with the categories. They also concurred that the casualty drag (19D/19K) and Tactical Road March tasks (19D) were important, unique capabilities that should be simulated and tested.

The 19D categories and tasks were:

a. Heavy Lifting: Evacuate a casualty from a Bradley Fighting Vehicle (BFV), install the barrel of a 25 mm gun on a BFV, remove the feeder assembly on the BFV and Load a TOW Missile into the launcher on a BFV.
b. Repetitive Lifting and Carrying: Carry sandbags to prepare a fighting position, load 25mm ammunition.
c. Drag: Drag a casualty to immediate safety.
d. Load Carriage: Conduct a tactical movement.

The 19K categories and tasks were:

a. Heavy Lifting: Casualty evacuation from a an M1 Abrams tank, Mount an M2 .50 caliber machine gun.
b. Repetitive Lifting and Carrying: Carry sandbags to prepare a fighting position, and Stow ammunition on an M1 Abrams tank.

c. Drag: Drag a casualty to immediate safety.
d. Load Carriage: Conduct a tactical movement.
e. Repetitive Lifting: Load the 120mm main gun.

For task categories with more than one task, the next step was to select the task that is the most physically demanding and/or the most mission critical. This is the task to be simulated. Based on the performance data collected, as well as practical considerations, USARIEM recommended tasks from each category. The OCOA personnel concurred with most of our recommendations and agreed that these tasks captured the critical physical demands of 19D and 19K Soldiers.

The 19D tasks selected for simulation were:

a. Evacuate a casualty from a BFV. The weight of the casualty described in the task is as heavy or heavier than other items evaluated in this category. Additionally, evacuating a casualty is common to other MOSs, it can be tested individually, requires minimum skill, and is critical to the safety and success of the mission.
b. Carry sandbags to prepare a fighting position. The described task utilizes a 40-lb sandbag (a weight similar to 25mm ammunition cans). Preparing a fighting position is also common to many MOSs, the equipment is readily available, and is physically demanding (high heart rate and energy cost). Additionally, a unique characteristic of carrying sandbags is the requirement for significant grip strength.
c. Drag a casualty to immediate safety. This task is the only task in this category, and is considered both physically demanding and essential to the safety of the Soldier.
d. Conduct a tactical movement. This task is essential to the performance of a 19D, and is the only task of its type.
e. Agility: Move under direct fire.

The 19K tasks selected for simulation were:

a. Evacuate a casualty from a Bradley Fighting Vehicle. The weight of the casualty described in the task is as heavy or heavier than other items evaluated in this category. Additionally, evacuating a casualty is common to other MOSs, it can be tested individually, requires minimum skill, and is critical to the safety and success of the mission.
b. Stow ammunition on an M1 Abrams tank. This is an essential task for a 19K and is as physically demanding as the sandbag carry. It requires a lift to a greater height.
c. Drag a casualty to immediate safety. This task is the only task in this category, and is considered both physically demanding and critical for Soldier safety.
d. Conduct a tactical movement. This task is important to the performance of a 19K, and is the only task of its type.

e. Load the 120mm main gun. This is a unique and essential task for the 19K.
f. Agility: Move under direct fire.

The SMEs provided their analysis and feedback of the task simulations. They agreed that the simulations captured the essential physical demands of the tasks. They suggested task 9 (move over, through and around obstable) and task 10 (move under direct fire) should be added to the 19D task list. USARIEM agreed and suggested this might also be added to all the MOSs where tactical road marching is an essential task. A short description of each task simulation follows:

Evacuate a Casualty Out of a BFV Gunner's Hatch or M1 Abrams Loader's Hatch. This task will be simulated using a platform and a heavy bag. A heavy bag is a long bag with reinforced handles used for weight training. It is about the same length as the average torso and head of a Soldier. While wearing a fighting load minus the weapon (approximately 71 lb), a Soldier will squat, grasp the handles of the heavy bag level with the floor, then stand and pull the bag through the hole in the platform, which will be sized for a BFV gunner's hatch or an M1 Abrams loader's hatch. The heavy bag will be placed onto the platform for successful task completion. The initial load of 50 lb will be used for familiarization and warm-up. With the successful completion of the lift, the weight of the simulated casualty will be increased in 10 lb increments and the lift will be repeated until the participating Soldier reaches volitional fatigue or a max load of 210 lb, representing their maximal heavy lift ability for a casualty evacuation task. The final load will be recorded.

Drag a Casualty. While wearing a fighting load with a weapon (approximately 83 lb), Soldiers will drag a simulated casualty (approximately 270 lb) up to 15 m as fast as possible in 60 seconds. The time to completion will be recorded. If the Soldier fails to pull the casualty 15 m in 60 seconds, the distance the casualty was dragged will be measured.

Sandbag Carry. While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers will lift and carry a total of 16 sandbags weighing 40 lb, carry them 10 m, and place them on the floor as quickly as possible. The time to completion will be recorded.

Tactical Foot March. The Soldiers will complete a movement of four miles, while wearing the basic Soldier uniform, personal protective equipment (to include weapon), and 24-hour sustainment load (approximately 103 lb). Soldiers will complete this task as quickly as possible while walking on a supervised course. Soldiers will not be allowed to run or do the airborne shuffle, but can take breaks as needed.

Load the 120mm Main Gun on an Abrams Tank. While wearing 49 lb of task specific equipment, Soldiers will load five 120mm .MPAT rounds (approximately 55 lb each) into a simulated breach of the Abrams tank main gun as quickly as possible. Time to complete the task will be recorded.

Stow Ammunition on Abrams Tank. While wearing a fighting load minus the weapon (approximately 71 lb), Soldiers will move 18-120mm MPAT rounds (approximately 55 lb each) from an ammunition point and place it onto a platform 5 m away. Time to complete the task will be recorded.

Move Under Fire Task. Soldiers will be wearing a fighting load (approximately 83 lb) and carrying a weapon at the ready. The task is initiated in the prone position. Upon command, Soldier will quickly stand and sprint approximately 5 to 8 m to a marker and assume the predetermined position for that marker (either the kneeling, crouched or prone position). They will remain in this position for approximately 5 seconds. Upon signal, Soldiers will get up and sprint approximately 5 to 8 m to the next marker and assume the predetermined position for that marker. This will be repeated until they have sprinted a total of 100 m. Time to complete the task and each sprint will be recorded. Each testing session will take approximately 1-2 minutes.

In December 2014 a study will be conducted at Ft. Carson, CO to determine the reliability of the load the main gun, stow ammunition in an M1 Abrams and Tactical Foot March tasks. Reliability testing has previously been completed for the casualty drag, casualty evacuation and sandbag carry at JB Lewis-McChord in May 2014. The two Armor tasks will be performed four (4) times over a two week period to determine if the scores change over repeated measurements.

In April 2015 a study will be conducted at Ft. Carson, CO to identify simple physical fitness tests that can be used to predict performance on the task simulations. These predictor tests are likely to include tests such as a standing long jump, a medicine ball put, and a 300 m run. The data from the predictor tests will be used to create a predictive equation to predict Soldier performance on the task simulations. TRADOC will determine when and where these tests are conducted.

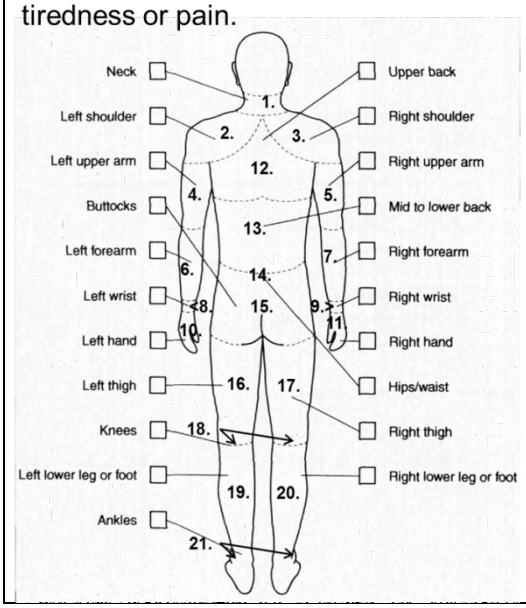
Prior to identifying suggested courses of action, SMEs must determine the minimal level of acceptable performance on each of the task simulations. For example, what is the longest acceptable time to complete the sandbag carry, the casualty drag, the foot march or the stow the ammunition task simulations? Once these have been agreed upon by the four Branch Proponents, the data can be appropriately analyzed.

The OCOA was extremely generous with their time and provided us with important insights regarding our testing and task simulations. Mr. DeSario and SGM Proft are planning to visit USARIEM 22 October to further assess the task simulations. The OCOA will also be represented at the testing in Ft Carson in December.

APPENDIX F. 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 G. TASK INSTRUCTIONS FROM STUDY 1

1. Conduct a Tactical Movement (24-hour Sustainment Load and Weapon) (19D and 19K)

The purpose of this task is to assess the physical demands of a tactical road march. In this task, you will walk at a pace of 1.5 to 2.0 miles per hour for 12 miles with 103 lb of equipment. We will issue you a heart rate monitor and a SPORTident stick. Some of you will also be issued a GPS. Please make sure the chest strap on your heart rate monitor is tight so it doesn't fall down while you are walking and that your heart rate is displayed on the watch. You will be weighed at the start, middle and end of the road march. Please stay well hydrated.

This is an individual event, so you do not have to walk in groups. If one of the Soldiers around you stops, and you don't need to stop, please continue walking. You will be started with your group of four Soldiers. At the start you will place the SPORTident stick in the "CLEAR" station, then the "Start" Station, when it beeps your time will begin. Your pace on the course should be a walking pace of about 1.5 mph; do not run, jog or do the airborne shuffle.

Along the course there will be Control Stations at 3, 6 and 9 miles. You will take a mandatory break at these Control Stations. The break will be 10 minutes at mile 3, 30 minutes at mile 6 and 10 minutes at mile 9. You can rest longer at these Control Stations and you can rest at any time along the course. When you approach each control station you will insert the SPORTident stick into the station, and report your subject number, RPE, Pain Soreness and Discomfort, and heart rate to the technician at the Control Station. (Review RPE & Pain Soreness and Discomfort Scales). You will be instructed to wait in a specific area. When your mandatory rest time is completed, you will be given a two minute warning and notified when the mandatory time is up. As you re-enter the course, you will insert your SPORTident stick into the exit station until it beeps and resume walking.

You will also pass checkpoints placed approximately every mile where your stick will beep. You don't need to do anything for these mileage checkpoints, just continue to walk.

There will be medics, water and latrines at each of the Control Stations. If you need medical assistance or cannot continue, please stop and wait for assistance. If you see someone who needs assistance, notify a medic or any test administrator on the course. In case of medical emergency, please call *********. If you stop for any reason, other than a medical emergency, please report back to the finish line. We need to determine why you stopped and collect the equipment from you.
Again, this is not a race. We are trying to determine what it takes to complete this task at the standard level of performance.
Do you have any questions?

3. *Prepare a Fighting Position (Fill and Emplace Sandbags) (19D and 19K)*

The purpose of this task is to fill buckets with sand and emplace 26 sandbags into a fighting position. 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. During

the task, you will wear a face mask attached to a small device worn on your back called an Oxycon, which measures your energy consumption. When told to begin, you will fill 26 buckets with sand up to the taped line using an entrenchment tool. You will have 52 minutes to complete this portion of the task. After filling the buckets 26 times, you will rate how hard you worked during the task on a scale from 6-20. You will then move to the sandbag pile and carry 26 sandbags 10 m where you will build a fighting position. Keep the sandbags within the taped outline and place 3 bags on each of the 3 sides outlined on the floor. Place the remainder of the sandbags on top of the first rows. One side will only have two bags on the top row. You will have 26 minutes to complete this portion of the task. Upon completion of the sandbag carry, you will rate how hard you worked using the same scale from 6-20 (show scale, read instructions). You should perform both tasks at a pace at which you can complete the task while maintaining your safety. Do you have any questions?

4a. ***Drag a Casualty to Immediate Safety (Dismounted) (19D and 19K)***

The purpose of this task is to assess the physical demands of dragging a casualty to safety. 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 drag a casualty weighing 270 lb a distance of 15 m as quickly as possible (from the 1st set of cones to the 2nd set of cones). The task isn't over until the casualty's feet cross the finish line. Upon completion of the task, we will record your heart rate and you will rate how hard you think you worked during the task on a scale from 0-10 (show scale, read instructions). You should perform the task at a pace at which you can complete the task while maintaining your safety. You will have 3 minutes to complete the test. If at any point you feel you are unable to continue, the test will be terminated. You will be given an opportunity to drag the dummy prior to performing the test to get a feel for the weight. Do you have any questions?

4b. ***Remove a Casualty from a Vehicle (Mounted) (19D)***

Condition 1:

The purpose of this test is to assess the physical demands of evacuating a 207-lb casualty from a wheeled vehicle. Prior to beginning you will jog in place and stretch to warm up. You will perform this task under two conditions. In the first condition, you will be working with a partner. The casualty will weigh 207 lb, which is the weight of the average Soldier wearing a modified fighting load. You will climb to the top of the BFV. You and your partner should squat or kneel down, grasp the shoulder straps and pull the casualty out through the commander's hatch. You will have 2 minutes to complete this task. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions). Get into a good position for lifting to protect your lower back. If you feel any pain or discomfort, you should stop performing the task. Do you have any questions?

Condition 2:

When working alone, you will lift 103 lb, which represents 1/2 of the weight of an average Soldier wearing a modified fighting load. Prior to beginning you will jog in place and stretch to warm up. Again, you will squat or kneel down, grasp the shoulder straps and pull the casualty out through the commander's hatch. You will have 2 minutes to complete this task. Upon completion of each condition, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions). Get into a good position for lifting to protect your lower back. If you feel any pain or discomfort, you should stop performing the task. Do you have any questions?

5. *Lift, Carry, and Install the Barrel of a 25mm Gun on the Bradley Fighting Vehicle (BFV) (19D)*

The purpose of this task is to assess the physical demands of lifting, carrying, and installing the 107 lb barrel of a 25mm Gun on a BFV. In this task, you and a partner will carry the 107 lb barrel 25 m from the 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 Soldier on the hull will stabilize the barrel while the second Soldier climbs up onto the hull. The barrel will be lifted and placed into the opening mount. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale and read instructions). It is important that you are careful with the equipment. You should perform the task at a pace at which you can complete the task while maintaining your safety. Do you have any questions?

6. *Remove the Feeder Assembly of a 25mm Gun on the Bradley Fighting Vehicle (BFV) (19D)*

The purpose of this task is to assess the physical demands of removing the M242 feeder assembly from the 25mm gun. When told to begin, you will remove the feeder assembly and place it on the floor of the vehicle on the spot marked with tape. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale and read instructions). You should perform the task at a pace at which you can complete the task while maintaining your safety. Do you have any questions?

7. *Load 25mm HEI-T Ammunition Cans onto the Bradley Fighting Vehicle (19D)*

The purpose of this task is to assess the physical demands of lifting, carrying and loading 30-25mm HEI-T Ammunition Cans onto a platform that simulates the tailgate of a BFV. Before we begin, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. You will wear a face mask attached to a small device worn on your back called an Oxycon, which measures your energy consumption. On command, you will lift one or two ammunition cans, carry them 15 m and place them onto a platform. Do not throw or drop the can on the platform or it will not count. You will repeat this until 30 cans have been moved. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 6-20 (show scale and read instructions). You should

perform the task at a pace at which you can complete the task while maintaining your safety. At any point if you feel you are unable to continue, stop and tell the administrator. Do you have any questions?

8. *Load TOW Missile Launcher on BFV (19D)*

The purpose of this test is to assess the physical demands of loading two 65 lb TOW Aero Missiles into the Bradley Fighting Vehicle Mounted TOW Weapon System. In this task, you will remove the TOW from the storage rack and lift it about 1 m from the crew compartment into the launcher. You will then remove it and replace it in the storage rack. Repeat a second time. Time will stop when the second missile is properly loaded. Upon completion, you will assess your personal rating of physical exertion on a scale of 1-10 (show scale, read instructions). It is important that you are careful with the equipment. You should perform the task at a pace at which you can complete the task while maintaining your safety. Do you have any questions?

17. Mount M2 .50 Cal Machine Gun Receiver on an Abrams Tank (19K)

The purpose of this task is to assess the physical demand of lifting and mounting an M2 .50 Cal Machine Gun receiver on an Abrams tank. In this task, you will lift the M2 .50 Cal Machine Gun receiver off the ground and place it on the hull of the tank. You will then climb up onto the hull, pick up the receiver and mount it on the turret. The task is complete once the receiver is securely mounted on the turret. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale and read instructions). It is important that you are careful with the equipment. You should perform the task at a pace at which you can complete the task while maintaining your safety. At any point if you feel you are unable to continue, stop and tell the administrator. Do you have any questions?

18. Stow Ammunition on an Abrams Tank (19K)

Ground to Hull Participant Instructions:

The purpose of this task is to assess the physical demands of lifting, carrying and stowing ammunition on an Abrams tank. Make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. You will wear a face mask attached to a small device worn on your back called an Oxycon, which measures your energy consumption. During this task, you lift and carry rounds 5m from the supply point to the tank and place it on the simulated hull of the tank. You will have 20 minutes to transfer all 36 rounds. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 6-20 (show scale and read instructions). You should perform the task at a pace at which you can complete the task while maintaining your safety. At any point if you feel you are unable to continue, stop and tell the administrator. Do you have any questions?

Turret to Rack Participant Instructions:

The purpose of this task is to assess the physical demands of stowing ammunition in the ammo rack on an Abrams tank. Make sure the chest strap of your

heart rate monitor is tight and that your heart rate is displayed on the watch. During this task, you will transfer rounds from the turret and place it in the ammo rack. You will have 20 minutes to stow all 36 rounds. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 6-20 (show scale and read instructions). You should perform the task at a pace at which you can complete the task while maintaining your safety. At any point if you feel you are unable to continue, stop and tell the administrator. Do you have any questions?

19. Load the 120mm Main Gun (19K)

The purpose of this task is to assess the physical demands of loading 5-120mm MPAT rounds in 35 seconds (one round every 7 seconds). Make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch. You will repeat this test twice, once in the real tank and once using a simulation. For each setting, you will move 5-120mm MPAT rounds weighing 55 lb from the ready rack to the breech. When performing the task inside the tank, you will be required to remove the round before installing the following round. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale and read instructions). You should perform the task at a pace at which you can complete the task while maintaining your safety. At any point if you feel you are unable to continue, stop and tell the administrator. Do you have any questions?

20. Remove a Casualty from an Abrams Tank (Mounted) (19K)

Condition 1 (Team of 3):

The purpose of this test is to assess the physical demands of evacuating a casualty from an Abrams Tank. Prior to beginning you will jog in place and stretch to warm up. You will perform this task under two conditions. In the first condition, you will be working with a team of 3. The casualty will weigh 225 lb, which is the weight of the average Soldier wearing a modified fighting load. Two of you will climb to the top of the Abrams Tank, and one will be inside. The individuals on top should squat or kneel down, grasp the shoulder straps and pull the casualty out through the commander's hatch. Upon completion of the task, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions). You will then rotate through the positions so that you perform the evacuation both from the top and inside.

Get into a good position for lifting to protect your lower back. If you feel any pain or discomfort, you should stop performing the task. Do you have any questions?

Condition 2 (Individual):

When working alone, you will lift 75 lb, which represents 1/3 of the weight of an average Soldier wearing a modified fighting load. Prior to beginning you will jog in place and stretch to warm up. Again, you will squat or kneel down, grasp the shoulder straps and pull the casualty out through the commander's hatch. Upon completion of each condition, you will be asked to rate how hard you worked during the task on a scale from 0-10 (show scale, read instructions). Get into a good

position for lifting to protect your lower back. If you feel any pain or discomfort, you should stop performing the task. Do you have any questions?

APPENDIX H. QUESTIONNAIRES, SURVEYS, AND DATA SHEETS FROM STUDY 1

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 3- Prepare Fighting Position

Oxycon Device Number: _____

Stopwatch Number: _____ Stopwatch Record #: _____

First Day Fighting Load Minus Weapon: _____

Filling Sandbags

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (6-20)*	*Pre HR (bpm)*	*Post HR (bpm)*	*Go/No Go*	
Weight within ± 3 lbs of First Day Fighting Load minus Weapon	____ : ____					

Comments:

Carrying Sandbags

	Time to Finish (Min:Sec)	*RPE (6-20)*	*Pre HR (bpm)*	*Post HR (bpm)*	*Go/No Go*	*Time of Day*
	____ : ____					

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 3- Prepare Fighting Position

Bag Number	**Fill** Sandbags (min:sec)
1	:
2	:
3	:
4	:
5	:
6	:
7	:
8	:
9	:
10	:
11	:
12	:
13	:
14	:
15	:
16	:
17	:
18	:
19	:
20	:
21	:
22	:
23	:
24	:
25	:
26	:

Bag Number	**Carry** Sandbags (min:sec)
1	:
2	:
3	:
4	:
5	:
6	:
7	:
8	:
9	:
10	:
11	:
12	:
13	:
14	:
15	:
16	:
17	:
18	:
19	:
20	:
21	:
22	:
23	:
24	:
25	:
26	:

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 4a- Drag a Casualty to Immediate Safety

First Day Fighting Load Weight (lbs): _____

FIGHTING LOAD Weight (lbs)	*Time (Min:Sec)*	*RPE (0-10)*	*Pre HR (bpm)*	*Final HR (bpm)*	*Go/ No Go*	*Time of Day*
Weight with ± 3 lbs of first day Fighting Load	____ : ____					

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 4b- Remove a Casualty from a Wheeled Vehicle (mounted)

First Day Fighting Load minus Weapon Weight (lbs): _____

Two Soldier Team

Team (circle one): Male-Male / Male-Female **Teammate Subject ID: _____**

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load Minus Weapon	____ : ____			

Comments:

Individually

	Time to Finish (Min:Sec)	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
	____ : ____			

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 5- Lift, Carry and Install the Barrel of a 25mm Gun

Team (circle one): Male-Male / Male-Female Teammate Subject ID: _____

First Day Fighting Load (lbs):_____

FIGHTING LOAD *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load	____ : ____			

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 6- Remove the Feeder Assembly of a 25mm Gun

First Day Body Weight (lbs): _____

39 LBS OF TASK SPECIFIC PPE *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go / No Go*	*Time of Day*
	____ : ____			

Task PPE = First Day Body Weight + 39lbs of Task Specific PPE
IOTVC with ESAPI and ESBI, CVC/ACH Helmet

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 7- Load 25mm H-EIT Tracer Ammunition Cans onto BFV

Oxycon Device Number: _____

Stopwatch Number:_____ Stopwatch Record #: _____

First Day Fighting Load minus Weapon Weight (lbs):_____

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (6-20)*	*Pre HR (bpm)*	*Final HR (bpm)*	*Go/ No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load minus Weapon	____ : ____					

Comments:

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

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 7- Load 25mm H-EIT Tracer Ammunition Cans onto BFV

Ammo Can Number	Time (min:sec)
1	:
2	:
3	:
4	:
5	:
6	:
7	:
8	:
9	:
10	:
11	:
12	:
13	:
14	:
15	:
16	:
17	:
18	:
19	:
20	:
21	:
22	:
23	:
24	:
25	:
26	:
27	:
28	:
29	:
30	:

Test Administrator's Initials _____

19D

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 8- Load TOW Missile Launcher on Bradley Fighting Vehicle

First Day Fighting Load minus Weapon (lbs):_____

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go/No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load minus Weapon	____ : ____			

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 17- Remove the Feeder Assembly of a 25mm Gun

First Day Body Weight (lbs): _____

37 LBS OF TASK SPECIFIC PPE *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go / No Go*	*Time of Day*
	____ : ____			

Task PPE = First Day Body Weight + 37lbs of Task Specific PPE
IOTVC with ESAPI and ESBI, CVC/ACH Helmet

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 18- Stow Ammunition on an Abrams Tank

GROUND to HULL

Oxycon Device Number: _____

Stopwatch Number:_____ Stopwatch Record #: _____

First Day Fighting Load minus Weapon Weight (lbs):_____

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (6-20)*	*Pre HR (bpm)*	*Final HR (bpm)*	*Go/No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load minus Weapon	____ : ____					

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 18- Stow Ammunition on an Abrams Tank

GROUND to HULL

Round Number	Time (min:sec)
1	:
2	:
3	:
4	:
5	:
6	:
7	:
8	:
9	:
10	:
11	:
12	:
13	:
14	:
15	:
16	:
17	:
18	:

Round Number	Time (min:sec)
19	:
20	:
21	:
22	:
23	:
24	:
25	:
26	:
27	:
28	:
29	:
30	:
31	:
32	:
33	:
34	:
35	:
36	:

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 18- Stow Ammunition on an Abrams Tank

TURRET TO READY RACK

Stopwatch Number:_____ **Stopwatch Record #:** _____

First Day Fighting Load minus Weapon Weight (lbs):_____

FIGHTING LOAD MINUS WEAPON *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (6-20)*	*Pre HR (bpm)*	*Final HR (bpm)*	*Go/No Go*	*Time of Day*
Weight within ± 3 lbs of first day Fighting Load minus Weapon	____ : ____					

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 18- Stow Ammunition on an Abrams Tank

TURRET TO READY RACK

Round Number	Time (min:sec)
1	:
2	:
3	:
4	:
5	:
6	:
7	:
8	:
9	:
10	:
11	:
12	:
13	:
14	:
15	:
16	:
17	:
18	:

Round Number	Time (min:sec)
19	:
20	:
21	:
22	:
23	:
24	:
25	:
26	:
27	:
28	:
29	:
30	:
31	:
32	:
33	:
34	:
35	:
36	:

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 19- Load the 120mm Main Gun on an Abrams Tank

First Day Body Weight (lbs): _____

INSIDE

37 LBS OF TASK SPECIFIC PPE *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go / No Go*	*Time of Day*
	____ : ____			

Task PPE = First Day Body Weight + 37 lbs of Task Specific PPE
IOTVC with ESAPI and ESBI, CVC/ACH Helmet

Round	Time (min:sec)
1	:
2	:
3	:
4	:
5	:

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 19- Load the 120mm Main Gun on an Abrams Tank

First Day Body Weight (lbs): _____

SIMULATION

	Time to Finish (Min:Sec)	*RPE (0-10)*	*Go / No Go*	*Time of Day*
	____ : ____			

Round	Time (min:sec)
1	:
2	:
3	:
4	:
5	:

Comments:

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

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 20- Remove a Casualty from an Abrams Tank

First Day Body Weight (lbs): _____

Three Soldier Team: TOP

Top Teammate (circle one): Male Female Teammate Subject ID: _____

Bottom Teammate (circle one): Male Female Teammate Subject ID: _____

37 LBS OF TASK SPECIFIC PPE *Weight (lbs)*	*Time to Finish (Min:Sec)*	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
	____ : ____			

Task PPE = First Day Body Weight + 37 lbs of Task Specific PPE
IOTVC with ESAPI and ESBI, CVC/ACH Helmet

Comments:

Three Soldier Team: BOTTOM

Top Teammate 1 (circle one): Male Female Teammate Subject ID: _____

Top Teammate 2 (circle one): Male Female Teammate Subject ID: _____

	Time to Finish (Min:Sec)	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
	____ : ____			

Comments:

Test Administrator's Initials _____

19K

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study

Task 20- Remove a Casualty from an Abrams Tank

Individually

	Time to Finish (Min:Sec)	*RPE (0-10)*	*Go/ No Go*	*Time of Day*
	____ : ____			

Comments:

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

Test Administrator's Initials _____

APPENDIX I. TASK INSTRUCTIONS FROM STUDY 2

1. Conduct a Tactical Movement (24-hour Sustainment Load and Weapon)

The purpose of the test is to determine the reliability of a road march test. You will walk four miles as fast as possible without running or doing the airborne shuffle. To start you will insert your SPORTident stick into the start receptacle. As soon as it beeps, your time is running. Walk on the right side of the road out and back. At each ½ mile and mile mark, there will be a set of cones. Walk in-between the two cones on the right side of the road. You should hear a beep from your stick as you pass, but you don't need to do anything. As you walk through the cones marked mile 4, check your heart rate and remember the number.

When you get to the finish cones, punch out with your SPORTident stick. Upon completion of the task, you will be asked for your heart rate. Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task.

Next we will ask you to point out the pain, soreness and discomfort you experienced during the march. Identify all regions in which you are currently feeling any discomfort and then rate that discomfort from 0 (No Discomfort) to 3 (Extreme Discomfort). If you are not experiencing any discomfort, you may skip that region.

To complete participation you will return the SPORTident stick at station 3, get weighed and return your weights at station 2, return your weapon to the truck, and return your heart watch and strap to station 1. Do you have any questions?

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

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 m where you will build a fighting position that is 4 sandbags wide, 2 sandbags deep, and two sandbags tall (Figure A). 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?

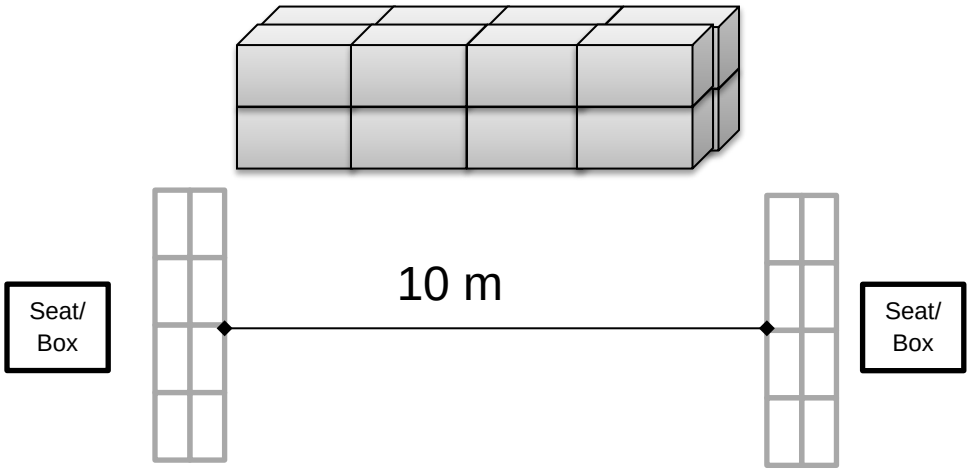


Figure A. Overhead layout.

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

The purpose of this task is to determine reliability of quickly dragging a 270-lb casualty a distance of 15 m. 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 30 seconds, I'll tell you when to stop (Figure A). 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 (Figure B). 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?

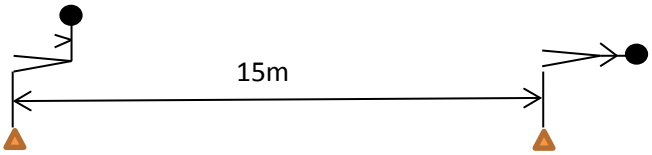


Figure A. If completed task (Record 15m and actual completion time)

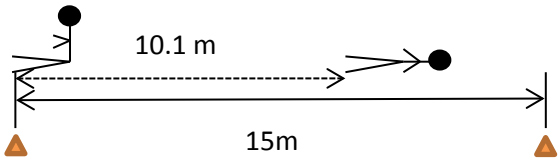


Figure B. If task not completed (Record 30 seconds & Distance to feet)

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

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 turret. The weight of the bag will begin at 50 lb. 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 lb 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 lb.

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

10. *Move Under Direct Fire*

The purpose of this task is to determine the reliability of a test simulating moving 100 m under direct fire. Make sure the chest strap of your heart rate monitor is tight and your heart rate is displayed on the watch (check now). You will begin the test lying in an unsupported prone fighting position.

When told to begin, the first timing station will light up and beep. You will rise and sprint to the first marker, get right next to the marker, and assume a kneeling fighting position. The marker should be right in front of you so you can make sure the light turns off. It is OK to touch the light. After 5 seconds, the second marker will light up and beep. You will sprint, get right next to the marker, and assume a kneeling fighting position. Again, make sure the light on the marker turns off. You will continue sprinting between markers in a similar manner, cycling between 1 prone, and 2 kneeling positions, until you have completed the entire course (Figure A).

You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. Once you start the test, do not stop unless it is an emergency. You should continue even if you stumble, as you may not be allowed to restart. Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show

scale). Look at this rating scale: 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

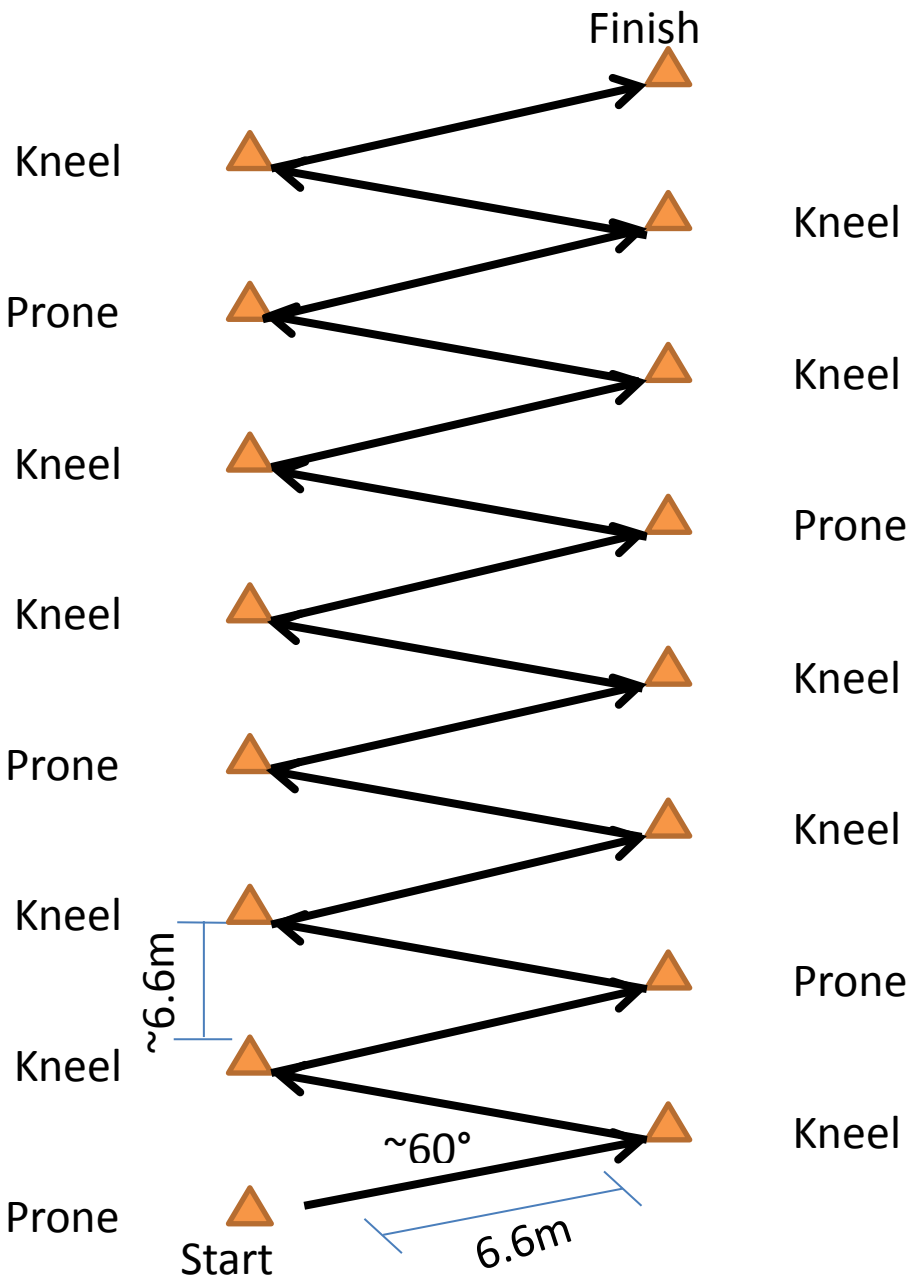


Figure A. Course Diagram.

18*. Stow Ammunition on an Abrams Tank (Load 120mm MPAT Round to the Ready Rack)*

The purpose of this task is to assess the reliability of a test designed to simulate lifting and carrying ammunition to an Abrams tank. Make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch (check now). Also, make sure your gloves are on.

During this task, you will lift and carry 18 rounds 5 m from the supply point to the tank and lift it onto a table simulating a Soldier on the hull of the tank. While carrying the rounds, one hand should be over the aft-cap while the other is supporting the weight (demonstrate). When lifting the rounds at the table, you should do it in a safe manner. Do not throw them or slam them in the table. You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. If at any point you feel you are unable to continue, the test will be terminated.

Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

19. *Load the 120mm Main Gun*

The purpose of this task is to determine the reliability of a test simulating moving 5 MPAT Rounds from the Ready Rack into the Breach of an Abrams tank. Make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch (check now). Also, make sure your gloves are on.

Inside the Abrams tank simulation, you will move five 120mm MPAT rounds. You will grab a round from the bustle rack, do a proper flip, and then push the round into the simulated breach. After each round you will hit a light which will turn red to provide you with a 1 second delay, simulating the firing of the gun. When the light turns green, you will grab the next round and repeat this process until you have loaded all 5 rounds. Prior to starting, you will be given an opportunity to practice the proper technique. Once you have mastered the technique, we will begin the testing. Each person will complete the testing 3 times. You will rotate through in round robin order.

You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. If at any point you feel you are unable to continue, the test will be terminated.

Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

APPENDIX J. QUESTIONNAIRES AND SURVEYS FROM STUDY 2

Physical Performance Standards Study

Demographics Sheet

(To be filled out by investigator)
Height (in)
_____
ACU Unloaded (lbs)
_____
Fighting Load minus Weapon (lbs)
_____
Fighting Load (lbs)
_____
Approach March Load (lbs)
_____

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) _____

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			
2			
3			
4			
5			
6			
7			

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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	:	
	:	
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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

	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

Page ____ of ____

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

Date: _____ **Data Collector:** _____

Test Repetition Number: 1 2 3 4

	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

Page ____ of ____

APPENDIX K. TASK INSTRUCTIONS FROM STUDY 3

Conduct a Tactical Movement

The purpose of the test is to determine the ability for simple tests to predict performance on a 4-mile road march. You will walk four miles as fast as possible without running or doing the airborne shuffle. Your weapon should be held at the ready in front of you at all times. To start you will insert your SPORTident stick into the clear and test receptacles. You will report your heart rate, then insert your Sportident into the start receptacle. As soon as it beeps, your time is running. Walk on the right side of the road out and back. At each ½ mile and mile mark, there will be a set of cones. Walk in-between the two cones on the right side of the road. You should hear a beep from your stick as you pass, but you don't need to do anything. Do NOT stop to rest at the cones because your stick will keep recording times. Move at least 25 feet away before you stop. As you walk through the cones marked mile 4, check your heart rate and remember the number.

When you get to the finish cones, punch out with your SPORTident stick. Upon completion of the task, you will report your heart rate. You will also rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 6 means "no exertion at all," and 20 means "maximal exertion."

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

Next we will ask you to point out the pain, soreness and discomfort you experienced during the march. Identify all regions in which you are currently feeling any discomfort and then rate that discomfort from 0 (No Discomfort) to 3 (Extreme Discomfort). If you are not experiencing any discomfort, you may skip that region.

To complete participation you will return the SPORTident stick, return your weapon to the supply closet, return your weights, and return your heart watch and strap to station 1. Do you have any questions

Prepare a Fighting Position (Sandbag Carry and Emplace)

The purpose of this task is to determine the relationship between performance of carrying and emplacing 16 filled sandbags 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 m where you will build a fighting position that is 4 sandbags wide, 2 sandbags deep, and two sandbags tall (Figure A). 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 be asked for your heart rate. You will also rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 6 means "no exertion at all," and 20 means "maximal exertion."

Try to rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

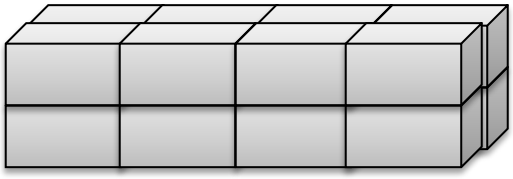
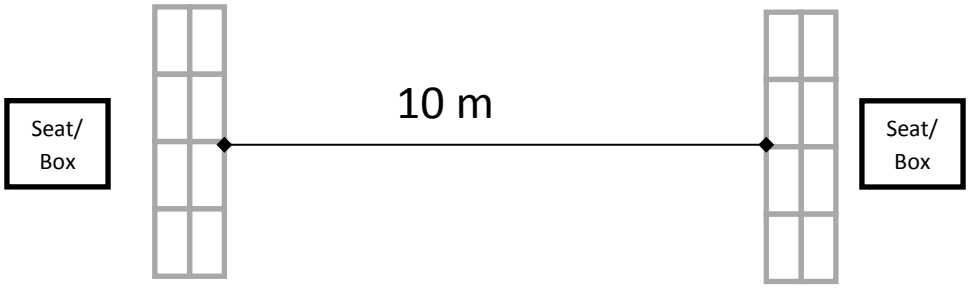


Figure A. Design of fighting position.



Casualty Drag

The purpose of this task is to determine the relationship between performance of dragging a 270-lb casualty a distance of 15 m 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 60 seconds to complete this task and I will count down the last 5 seconds and say 'stop'. If you cross the finish line within 60s, I'll tell you when to stop (Figure A). 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 (Figure B). I will measure how far you dragged it.

Upon completion of the task, you will rate your physical effort on a scale from 0-10. This rating should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people (show scale). Look at this rating scale: 0 means "no exertion at all," and 10 means "Extremely Hard."

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?

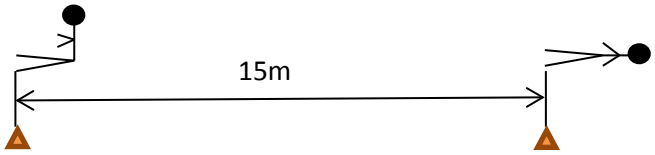


Figure A. If completed task (Record 15m and actual completion time)

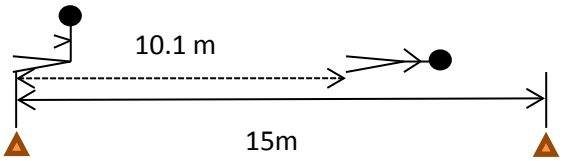


Figure B. If task not completed (Record 30 seconds and Distance to feet)

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 turret, and simple predictive tests. 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.

Make sure you are wearing gloves. Prior to starting we will review proper lifting technique using a set of 25 lb kettlebells. You will be required to use good technique on every lift 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 weight and stop performing the task.

After everyone has completed the 50 lb, we will cycle through everyone again. You may choose add 10, 20, or 30 lb to the bag after each successful lift; however, the tester may ask you to perform a lower weight if it is deemed appropriate. The maximum lift for this test is 210 lb. You may be skipped during some cycles in order to minimize the time we spend adjusting the bag.

Upon completion of each lift, you will rate your physical effort on a scale from 0-10. This rating should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people (show scale). Look at this rating scale: 0 means "no exertion at all," and 10 means "Extremely Hard."

Your rating should reflect only your effort for that particular weight, and not be solely based on whether or not you lifted the bag. Do you have any questions?

Move Under Direct Fire

The purpose of this task is to determine the relationship between performance of a test designed to simulate moving 100 m under direct fire and simple predictor tests. Make sure the chest strap of your heart rate monitor is tight and your heart rate is displayed on the watch (check now). You will begin the test lying in an unsupported prone fighting position.

When told to begin, you will rise and sprint to the first marker. Get right next to the marker and assume a kneeling fighting position. After 5 seconds, we will cue you to run to the next marker. You will sprint, get right next to the 2nd marker, and again assume a kneeling fighting position. You will continue sprinting between markers in a similar manner, cycling between 1 prone, and 2 kneeling positions, until you have completed the entire course. The signs next to each cone will instruct you whether to kneel or get prone. When getting up, you may not use the barrel of the gun for support. On the final sprint, run straight through the finish line.

You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. Once you start the test, do not stop unless it is an emergency. You should continue even if you stumble, as you may not be allowed to restart. Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 6 means “no exertion at all,” and 20 means “maximal exertion.”

Try to rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

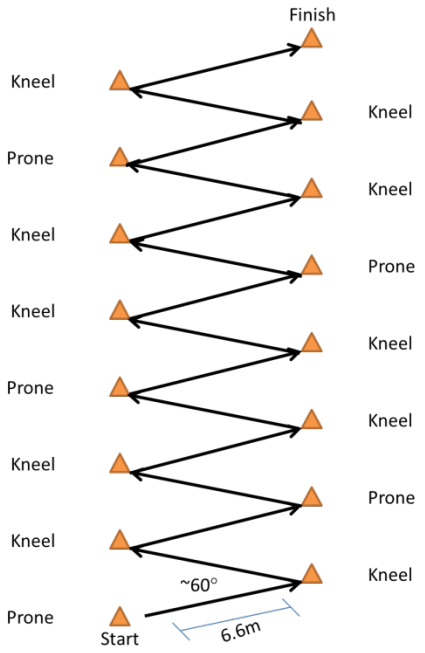


Figure A. Course Diagram Option 1

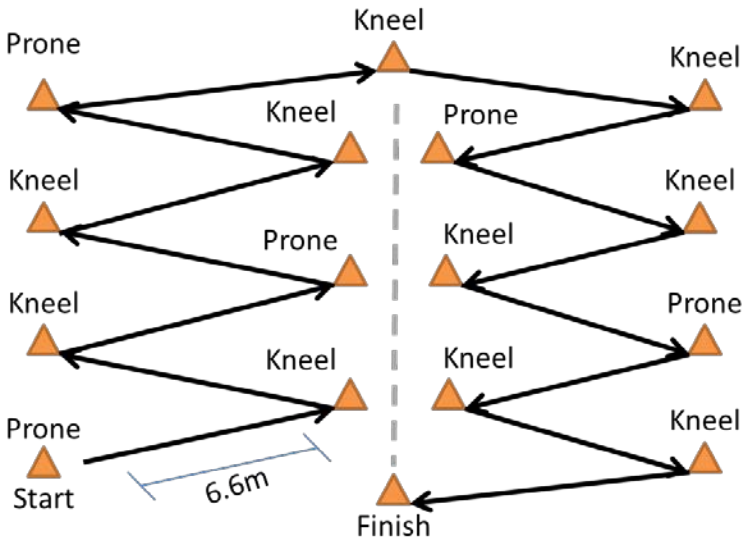


Figure B. Course Diagram Option 2

Stow Ammunition on an Abrams Tank (Stow Ammo)

The purpose of this task is to determine the relationship between performance of a test designed to simulate lifting and carrying ammunition to an Abrams tank and simple predictor tests. Make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch (check now). Also, make sure your gloves are on.

During this task, you will lift and carry 18 rounds 5 m from the supply point to the tank and lift it onto a table simulating a Soldier on the hull of the tank. While carrying the rounds, one hand should be over the aft-cap while the other is supporting the weight (demonstrate). When lifting the rounds at the table, you should do it in a safe manner. Do not throw them or slam them in the table. You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. If at any point you feel you are unable to continue, the test will be terminated.

Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

Load the 120mm Main Gun

The purpose of this task is to determine the relationship between performance of a test simulating moving 5 MPAT Rounds from the Ready Rack into the Breach of an Abrams tank and simple predictor tests. Before we begin, make sure the chest strap of your heart rate monitor is tight and that your heart rate is displayed on the watch (check now). Also, make sure your gloves are on.

Inside the Abrams tank simulation, you will move five 120mm MPAT rounds. You will grab a round from the bustle rack, do a proper flip or turn, and then push the round into the simulated breach. After each round you will hit the button simulating the firing of the gun. You will then grab the next round and repeat this process until you have loaded all 5 rounds. Prior to starting, you will be given an opportunity to practice the proper technique. Once you have mastered the technique, we will begin the testing. Each person will complete the testing 3 times. You will rotate through in round robin order.

You should perform the task as quickly as possible while maintaining your safety, but choose a pace at which you can complete the task. If at any point you feel you are unable to continue, the test will be terminated.

Upon completion of the task, you will be asked for your heart rate. You will also be asked to rate your physical effort on a scale from 6-20. This feeling should reflect your total amount of exertion, combining all sensations and feelings of physical stress 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 that is important, not how it compares to other people. Be as accurate as you can (show scale). Look at this rating scale: 6 means "no exertion at all," and 20 means "maximal exertion."

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>
> 13 corresponds to "somewhat hard" exertion, but it still feels OK to continue.
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> 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 rate your feeling of exertion as honestly as possible, without thinking about the actual job task or purpose of the task. Do you have any questions?

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 19D and 19K. You will jog, run, and then sprint continuously between the two lines 20 m 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 19D and 19K. 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?

Upright Pull at 38 cm

The purpose of this task is to determine the ability of an upright pull to predict performance of the physically demanding tasks of a 19D and 19K. 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 19D and 19K. 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 ergometer test to predict performance of the physically demanding tasks of a 19D and 19K. 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 ten 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?

Handgrip

The purpose of this task is to determine the ability of handgrip strength to predict performance of the physically demanding tasks of a 19D and 19K. 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 19D and 19K. 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 19D and 19K. 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 19D and 19K. During this test, you will run through a series of cones. (*Show Soldiers Figure A 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 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.

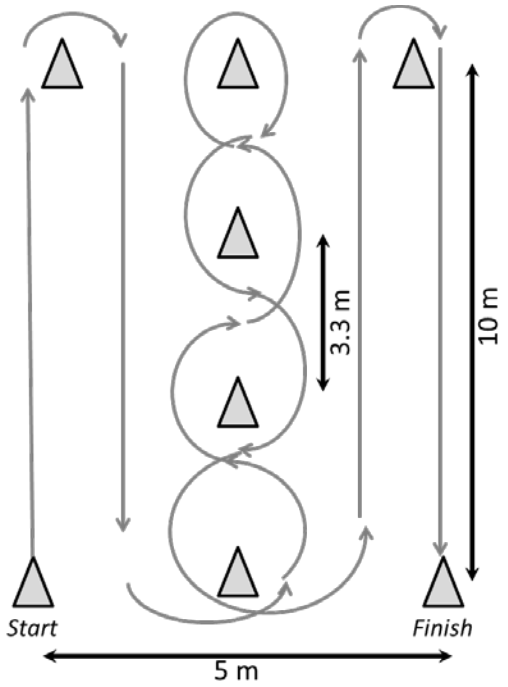

Figure A. Illinois Agility Course Outline

300 m Sprint

The purpose of this test is to assess the ability of the 300 m sprint test to predict performance of the physically demanding tasks of a 19D and 19K. 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 m. The test is complete when you cross the finish line. Run the 300 m 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?

Resistance Pull (with sled)

The purpose of this test is to assess the ability of the Resistance Pull test to predict performance of the physically demanding tasks of a 19D and 19K. You will be asked to run backwards 20 m while holding a 24-kg kettlebell attached to a sled providing resistance.

You will begin with your back facing the direction you will be running. When ready, you will pick up the kettlebell with two hands side by side, and I will give you a "3, 2, 1, Go" countdown. On the "Go" command, run backwards as fast as you can while maintaining your safety. I will let you know when you cross the finish line. Time stops when the sled crosses the line, not your body. If you don't cross the line in 90 seconds, I will give you a "5, 4, 3, 2, 1, stop" countdown. On the "stop" command, stop where you are, and I will measure how far you ran. If you fall during the test, attempt to get up and keep going. If at any point you feel you are unable to continue, the test can be terminated. Do you have any questions?

Powerball Throw

The purpose of this test is to assess the ability of the Powerball Throw test to predict performance of the physically demanding tasks of a 19D and 19K. During the test, you will be standing with your back facing the direction you will be throwing. Your feet should be shoulder width apart with your heels on the “zero”/ start line.

(Demonstrate while describing motion) You will begin the throw with the ball in both hands, held over your head. While keeping your arms extended, swing the ball down between your legs while flexing your knees, hips and trunk. After you have reached a squatting position, thrust your hips forward, extend your knees and trunk, flex your shoulders, while in one motion, throw the ball back overhead.

You will be given two practice throws. After the practice throws you will be asked to complete three throws for record. If at any point you feel you are unable to continue, the test will be terminated. Do you have any questions?

Squat Lift

The purpose of this task is to determine the ability of a dumbbell squat test to predict performance of the physically demanding tasks of a 19D and 19K. Beginning with a pair of 25-lb dumbbells, you will squat, grasp handles, and complete a set of 3 to 5 squat lifts.

Prior to testing, make sure you are wearing gloves. (Demonstrate while explaining) You will begin by placing feet between the dumbbells about shoulder width apart. Make sure your knees are in line with toes. On the “set” command, bend at the hips and knees, sticking your butt back so that your back is flat or slightly arched. Keep your head up, and grip the dumbbells at your sides with your arms fully extended. When given the “lift” command, lift the dumbbells straight up by extending your knees and hips at the same time. Keep your head angled up. The dumbbells should stay as close to your legs as possible, and your arms should remain extended. When you are standing with your hips and knees fully straight, the test administrator will say “good” and you will squat back down and release the weights in their stands in a safe and controlled manner. If you show poor lifting technique or you drop the weights, we will stop you and you will not receive credit for that lift.

After you have completed the first weight, you will be given a short rest and then you’ll be asked to lift a pair of dumbbells 10 lb heavier. The maximum lift for this test is a pair of 110 lb dumbbells for a total load of 220 lb. If you fail to lift a load, you may try one more time after a brief rest.

Don’t overexert yourself trying to lift a weight that is too heavy. If you feel any pain or discomfort, you should put the dumbbell down and stop performing the task. 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 19D and 19K. 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 L. QUESTIONNAIRES AND SURVEYS FROM STUDY 3

Demographics

19D

Physical Performance Standards Study

Ft Carson, CO April 2015

Demographics Sheet

Subject ID_____

Sex _____

Age _____ **Date of Birth:** _____

Race *(Circle one or more)*

Caucasian African American Hispanic Asian Other: _____

MOS _____ **Rank** _____

Date of Last Army Physical Fitness Test_____

APFT Total Score _____

Push-ups (#) _____

Sit-ups (#) _____

2-Mile Run Time (min:sec) _____

19K

Physical Performance Standards Study 3

Demographics Sheet

Testing Site: Ft. Stewart (MAY/JUN 15) Ft. Riley (JUN 15)

Subject ID_____

Sex _____

Age _____ Date of Birth: _____

Race (circle one):

Caucasian African American Hispanic Asian

MOS _____ Rank _____

Date of Last Army Physical Fitness Test_____

APFT Total Score _____

Push-ups (reps) _____

Sit-ups (reps) _____

2-Mile Run Time (min:sec) _____

Training and Experience

19D

PDS Study 3: Carson 11B 11C 19D Validation
April 2015

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			
	Master Task Number/Master Task	Training (Y/N)	# of times	Deployment (Y/N)	# of times
1	Conduct a tactical movement of at least 4 miles wearing a fighting load				
3	Prepare a fighting position				
4a	Drag casualty to safety (dismounted)				
4b	Remove casualty from a vehicle (mounted)				
10	Move under direct fire				
	Answer below only if volunteering to complete the following task				
21	Transfer ammunition with an M993 Carrier (load M793 HE rounds into a CAT)				

19K

PDS Training & Deployment Questionnaire

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			
	Master Task Number/Master Task	Training (Y/N)	# of times	Deployed (Y/N)	# of times
1	Conduct a tactical movement of at least 4 miles wearing a fighting load				
2	Employ hand grenades				
3	Prepare a fighting position				
4a	Drag casualty to safety				
4b	Remove casualty from a vehicle				
10	Move Under Direct Fire (3-5 sec rushes)				
17	Mount M2 .50 Cal Machine Gun Receiver on an Abrams Tank				
18	Stow Ammunition on an Abrams Tank				
19	Load the 120mm Main Gun				

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
11B 11C 19D Carson APRIL 2015
Criterion Tasks

Sandbag Carry

Stopwatch Number: _____ **Stopwatch Record #:** _____

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

STAPLE STOPWATCH PRINTOUT TO STOPWATCH SHEET. NOTE ANY ISSUES WITH PRINTOUT BELOW.

Comments:

Move Under Direct Fire

Stopwatch Number: _____ **Stopwatch Record #:** _____

	Time to Finish (min:sec)	*RPE (6-20)*	*HR (bpm)*
Baseline			
Finish	:		

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
11B 11C 19D Carson APRIL 2015
Criterion Tasks

Casualty Extraction from BFV

Rep	*Bag Weight (lbs)*	*Completed (Y/N)*	*RPE (0-10)*
1			
2			
3			
4			
5			
6			
7			

Comments:

Casualty Drag

	Distance (m)	*Time to Finish (sec, up to 60)*	*RPE (0-10)*	*HR (bpm)*
Baseline				
Finish		:		

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
19K Criterion Tasks

Load the 120mm Main Gun on an Abrams Tank (5 Rounds)

Soldier Weight in *Mission Specific PPE* (lbs): _____

Stopwatch Number: _____

		Stopwatch Record #	*Time to Finish (Min:Sec)*	*RPE (6-20)*	*HR (bpm)*
Trial 1	**Baseline**				
	Finish		:		
Trial 2	**Baseline**				
	Finish		:		
Trial 3	**Baseline**				
	Finish		:		

STAPLE STOPWATCH PRINTOUT TO STOPWATCH SHEET. NOTE ANY ISSUES WITH PRINTOUT BELOW.

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
19K Criterion Tasks

Casualty Extraction from Abrams

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

Rep	*Bag Weight (lbs)*	*Completed (Y/N)*	*RPE (0-10)*
1			
2			
3			
4			
5			
6			
7			

Comments:

Stow Ammunition on an Abrams Tank (18 Rounds)

Soldier Weight *Fighting Load Minus WEAPON* (lbs): _____

Stopwatch Number: _____ Stopwatch Record #: _____

	Time to Finish (Min:Sec)	*Rounds Moved (#)*	*RPE (6-20)*	*HR (bpm)*
Baseline				
Finish	:			

STAPLE STOPWATCH PRINTOUT TO STOPWATCH SHEET. NOTE ANY ISSUES WITH PRINTOUT BELOW.
Comments:

Last Revised 17AUG2015

Date: _____ Data Collector: _____

USARIEM MOS Physical Performance Standards Study

Tactical Road March: Start Data Sheet

Subject #	Start Time	HR
	:	
	:	
	:	
	:	
	:	
	:	
	:	
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	:	
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	:	
	:	
	:	
	:	

Page ___ of ___

Date: _____ Data Collector: _____

USARIEM MOS Physical Performance Standards Study

Tactical Road March: Finish Data Sheet

Subject #	Finish Time	RPE	HR
	:		
	:		
	:		
	:		
	:		
	:		
	:		
	:		
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	:		
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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

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

Page ____ of ____

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
Predictive Tests

Beep Test

Check as Shuttle Completed

Level #	Shuttle # 1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													

Beep Test	*Level #*	*Shuttle #*	*Heart Rate (bpm)*
Baseline			
Finish			

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
Predictive Tests

				If Necessary	
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*
Medicine Ball Put (cm)					
Illinois Agility (min:sec)	:				

Comments:

				If Necessary	
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*
Upright Pull (lbs)					
Isometric Bicep Curl (lbs)					

Comments:

				If Necessary	
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*
Standing Broad Jump (m)					
One Minute Push Ups (#)					

Comments:

Resistance Pull Test	*Time* (min:sec)	*Distance (m)* *(if not completed)*	*Heart Rate (bpm)*
Baseline			
Finish *(up to 20m or 90 sec)*			

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
Predictive Tests

				If Necessary	
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*
Power Ball Throw (cm)					
One Minute Sit-Ups (#)					

Comments:

Arm Endurance	*Revolutions (#)*	*Heart Rate (bpm)*
Baseline		
Minute 1 (Halfway)		
Minute 2 (Finish)		

				If Necessary	
	Left 1	*Left 2*	*Left 3*	*Left 4*	*Left 5*
Handgrip (kg)					
	Right 1	*Right 2*	*Right 3*	*Right 4*	*Right 5*

Comments:

	Time (min:sec)
300 Meter Run (min:sec)	:

Comments:

Last Revised 17AUG2015

Subject ID: _____ Date: _____

USARIEM MOS Physical Performance Standards Study
Predictive Tests

Squat Lift (lbs)	*Completed (Y/N)*	*RPE (0-10)*
50		
60		
80		
100		
120		
140		
160		
180		
200		
220		

Comments:

Last Revised 17AUG2015

APPENDIX M. ADDITIONAL STATISTICAL TABLES FROM STUDY 3

19D Predictor Tests among other Predictor Tests

		Beep Test (#)	Med Ball Put (cm)	Illinois Agility (min)	Upright Pull (lb)	Biceps Curl (lb)	SLJ[1] (cm)	Push-up (#)
Beep Test (#)	r	----	0.37**	-0.54**	0.38**	0.38**	0.48**	0.50**
	N	----	134	134	134	134	134	134
Med Ball Put (cm)	r	0.37**	---	-0.565**	0.86**	0.90**	0.73**	0.68**
	N	134	----	134	134	134	134	134
Illinois Agility (min)	r	-0.54**	-0.57**	----	-0.56**	-0.55**	-0.65**	-0.52**
	N	134	134	----	134	134	134	134
Upright Pull (lb)	r	0.38**	0.86**	-0.559**	----	0.91**	0.76**	0.73**
	N	134	134	134	----	134	134	134
Biceps Curl (lb)	r	0.38**	0.90**	-0.549**	0.91**	----	0.76**	0.74**
	N	134	134	134	134	----	134	134
SLJ[1] (cm)	r	0.48**	0.73**	-0.65**	0.76**	0.76**	----	0.66**
	N	134	134	134	134	134	----	134
Push-up (#)	r	0.50**	0.68**	-0.52**	0.73**	0.74**	0.66**	----
	N	134	134	134	134	134	134	----
Resist. Pull (m/sec)	r	0.37**	0.90**	-0.535**	0.89**	0.89**	0.72**	0.62**
	N	134	134	134	134	134	134	134
Powerball Throw (cm)	r	0.38**	0.88**	-0.573**	0.90**	0.89**	0.75**	0.68**
	N	134	134	134	134	134	134	134
Sit-up (#)	r	0.30**	0.18*	-0.176*	0.19*	0.17	0.29**	0.41**
	N	134	134	134	134	134	134	134
ArmErg (RP2m)	r	0.43**	0.73**	-0.564**	0.75**	0.76**	0.64**	0.64**
	N	134	134	134	134	134	134	134
Handgrip (lb)	r	0.31**	0.80**	-0.5**	0.86**	0.86**	0.68**	0.68**
	N	134	134	134	134	134	134	134
300m Sprint (m)	r	-0.65**	-0.56**	0.613**	-0.56**	-0.54**	-0.74**	-0.59**
	N	134	134	134	134	134	134	134
Squat Lift (lb)	r	0.43**	0.72**	-0.508**	0.74**	0.71**	0.61**	0.50**
	N	134	134	134	134	134	134	134

**p<0.01; *p<0.05

[1] Standing Long Jump

19D Predictor Tests among other Predictor Tests (cont.)

		Resist. Pull (m/sec)	Power-ball Throw (cm)	Sit-up (#)	ArmErg (RP2m)	Hand-grip (lb)	300m Sprint (min)	Squat Lift (lb)
Beep Test (#)	r	0.37**	0.38**	0.30**	0.43**	0.31**	-0.65**	0.43**
	n	134	134	134	134	134	134	134
Med Ball Put (cm)	r	0.90**	0.88**	0.18*	0.73**	0.80**	-0.56**	0.72**
	n	134	134	134	134	134	134	134
Illinois Agility (min)	r	-0.54**	-0.57**	-0.18*	-0.56**	-0.50**	0.61**	-0.51**
	n	134	134	134	134	134	134	134
Upright Pull (lb)	r	0.89**	0.90**	0.19*	0.75**	0.86**	-0.56**	0.74**
	n	134	134	134	134	134	134	134
Biceps Curl (lb)	r	0.89**	0.89**	0.17*	0.76**	0.86**	-0.54**	0.71**
	n	134	134	134	134	134	134	134
SLJ[1] (cm)	r	0.72**	0.75**	0.29**	0.64**	0.68**	-0.74**	0.61**
	n	134	134	134	134	134	134	134
Push-up (#)	r	0.62**	0.68**	0.41**	0.64**	0.68**	-0.59**	0.50**
	n	134	134	134	134	134	134	134
Resist. Pull (m/sec)	r	----	0.90**	0.14	0.76**	0.81**	-0.51**	0.74**
	n	----	134	134	134	134	134	134
Powerball Throw (cm)	r	0.90**	----	0.18	0.75**	0.83**	-0.52**	0.70**
	n	134	----	134	134	134	134	134
Sit-ups (#)	r	0.14	0.18*	----	0.12	0.12	-0.35**	0.09
	n	134	134	----	134	134	134	134
ArmErg (RP2m)	r	0.76**	0.75**	0.12	----	0.76**	-0.58**	0.71**
	n	134	134	134	----	134	134	134
Handgrip (lb)	r	0.81**	0.83**	0.12	0.76**	----	-0.53**	0.65**
	n	134	134	134	134	----	134	134
300m Sprint (m)	r	-0.51**	-0.52**	-0.35**	-0.58**	-0.53**	----	-0.54**
	n	134	134	134	134	134	----	134
Squat Lift (lb)	r	0.74**	0.70**	0.09	0.71**	0.65**	-0.54**	----
	n	134	134	134	134	134	134	----

**p<0.01; *p<0.05

[1] Standing Long Jump

19K Predictor Tests among other Predictor Tests

		Beep Test (#)	Med Ball Put (cm)	Illinois Agility (min)	Upright Pull (lb)	Biceps Curl (lb)	SLJ[1] (cm)	Push-up (#)
Beep Test (#)	r	---	0.57	-0.68**	0.51**	0.53**	0.66**	0.73**
	n	---	185	185	185	185	185	185
Med Ball Put (cm)	r	0.57**	---	-0.67**	0.83**	0.83**	0.71**	0.67**
	n	185	---	186	185	185	186	185
Illinois Agility (min)	r	-0.68**	-0.67	---	-0.58**	-0.56**	-0.76**	-0.69**
	n	185	186	---	185	185	186	185
Upright Pull (lb)	r	0.51**	0.83	-0.58**	---	0.85**	0.70**	0.57**
	n	185	185	185	---	185	185	185
Biceps Curl (lb)	r	0.53**	0.83	-0.56**	0.85**	---	0.70**	0.65**
	n	185	185	185	185	---	185	185
SLJ [1] (cm)	r	0.66**	0.71	-0.76**	0.70**	0.70**	---	0.65**
	n	185	186	186	185	185	---	185
Push-Up (#)	r	0.73**	0.67	-0.69**	0.57**	0.65**	0.65**	---
	n	185	185	185	185	185	185	---
Resist. Pull (m/sec)	r	0.46**	0.71	-0.47**	0.74**	0.69**	0.62**	0.41**
	n	185	185	185	185	185	185	185
Powerball Throw (cm)	r	0.55**	0.86	-0.61**	0.87**	0.84**	0.75**	0.60**
	n	185	185	185	185	185	185	185
Sit-up (#)	r	0.36**	0.18	-0.34**	0.16*	0.24**	0.34**	0.43**
	n	185	185	185	185	185	185	185**
ArmErg (RP2m)	r	0.60**	0.68	-0.53**	0.71**	0.69**	0.56**	0.64**
	n	185	186	186	185	185	186	185
Handgrip (lb)	r	0.49**	0.82	-0.57**	0.87**	0.81**	0.66**	0.56**
	n	185	186	186	185	185	186	185
300m Sprint (m)	r	-0.75**	-0.68	0.66**	-0.66**	-0.62**	-0.74**	-0.69**
	n	184	184	184	184	184	184	184
Squat Lift (lb)	r	0.49**	0.73	-0.53**	0.74**	0.67**	0.61**	0.52**
	n	184	184	184	184	184	184	184

**p<0.01; *p<0.05

[1] Standing Long Jump

19K Predictor Tests among other Predictor Tests (continued)

		Resist. Pull (m/sec)	Power-ball Throw (cm)	Sit-up (#)	ArmErg (RP2m)	Hand-grip (lb)	300m Sprint (min)	Squat Lift (lb)
Beep Test (#)	r	0.46**	0.55**	0.36**	0.60**	0.49**	-0.75**	0.49**
	n	185	185	185	185	185	184	184
Med Ball Put (cm)	r	0.71**	0.86**	0.18*	0.68**	0.82**	-0.68**	0.73**
	n	185	185	185	186	186	184	184
Illinois Agility (min)	r	-0.47**	-0.61**	-0.34**	-0.53**	-0.57**	0.66**	-0.53**
	n	185	185	185	186	186	184	184
Upright Pull (lb)	r	0.74**	0.87**	0.16*	0.71**	0.87**	-0.66**	0.74**
	n	185	185	185	185	185	184	184
Biceps Curl (lb)	r	0.69**	0.84**	0.24**	0.69**	0.81**	-0.62**	0.67**
	n	185	185	185	185	185	184	184
SLJ [1] (cm)	r	0.62**	0.75**	0.34**	0.56**	0.66**	-0.74**	0.61**
	n	185	185	185	186	186	184	184
Push-up (#)	r	0.41**	0.60**	0.43**	0.64**	0.56**	-0.69**	0.52**
	n	185	185	185	185	185	184	184
Resist. Pull (m/sec)	r	---	0.80**	0.08	0.68**	0.71**	-0.63**	0.67**
	n	---	185	185	185	185	184	184
Powerball Throw (cm)	r	0.80**	---	0.22**	0.73**	0.85**	-0.72**	0.75**
	n	185	---	185	185	185	184	184
Sit-up (#)	r	0.08**	0.22**	---	0.27**	0.17*	-0.28**	0.17**
	n	185	185	---	185	185	184	184
ArmErg (RP2m)	r	0.68**	0.73**	0.27**	---	0.69**	-0.67**	0.66**
	n	185	185	185	---	186	184	184
Handgrip (lb)	r	0.71**	0.85**	0.17*	0.69**	---	-0.64**	0.70**
	n	185	185	185	186	---	184	184
300m Sprint (m)	r	-0.63**	-0.72**	-0.28**	-0.67**	-0.64**	---	-0.69**
	n	184	184	184	184	184	---	184
Squat Lift (lb)	r	0.67**	0.75**	0.17*	0.66**	0.70**	-0.69**	---
	n	184	184	184	184	184	184	---

**p<0.01; *p<0.05

[1] Standing Long Jump

19D Criterion Tasks among other Criterion Tasks

		Foot March (min)	Sandbag (min)	Move Under Fire (min)	BFV Cas Evac (lb)	Cas Drag (m/s)
Foot March (min)	r	---	0.67**	0.59**	-0.67**	-0.64**
	n	---	134	134	134	134
Sandbag (min)	r	0.67**	---	0.69**	-0.79**	-0.64**
	n	134	---	134	134	134
Move Under Fire (min)	r	0.59**	0.69**	---	-0.74**	-0.60**
	n	134	134	---	134	134
Cas Evac (lb)	r	-0.67**	-0.79**	-0.74**	---	0.73**
	n	134	134	134	---	134
BFV Cas Drag (m/s)	r	-0.64**	-0.64**	-0.60**	0.73**	---
	n	134	134	134	134	---

**p<0.01; *p<0.05

19K Criterion Tasks among other Criterion Tasks

		Foot March (min)	Move Under Fire (min)	Abrams Cas Evac (lb)	Casualty Drag (m/s)	Load Main Gun (sec)	Stow Ammo (rounds/ min)
Foot March (min)	r	---	0.49**	-0.61**	-0.54**	0.55**	-0.60**
	n	---	187	187	187	187	187
Move Under Fire (min)	r	0.49**	---	-0.67**	-0.67**	0.61**	-0.69**
	n	187	---	187	187	187	187
Abrams Cas Evac (lb)	r	-0.61**	0.67**	---	0.82**	-0.73**	0.79**
	n	187	187	---	187	187	187
Casualty Drag (m/s)	r	-0.54**	-0.67**	0.82**	---	-0.75**	0.83**
	n	187	187	187	---	187	187
Load Main Gun (sec)	r	0.65**	0.61**	-0.73**	-0.75**	---	-0.79**
	n	187	187	187	187	---	187
Stow Ammo (rounds/min)	r	-0.60**	-0.69**	0.79**	0.83**	-0.79**	---
	n	187	187	187	187	187	---

**p<0.01; *p<0.05

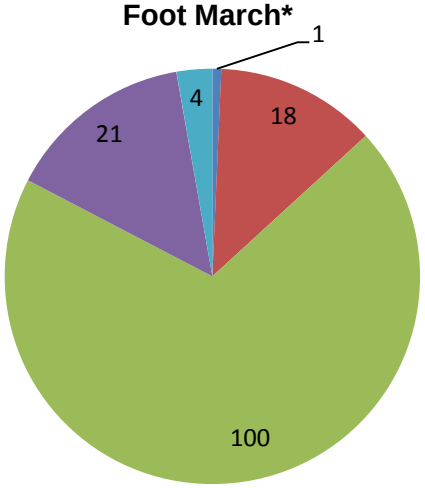
APPENDIX N. SUMMARY OF SME GRADING OF SOLDIER PERFORMANCE ON CRITERION TASKS FROM STUDY 3

19D Tasks: Pace

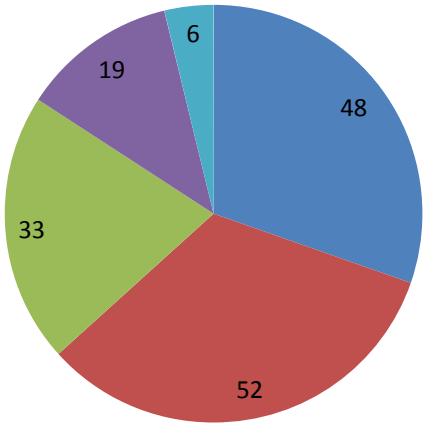
This Soldier is performing this task at a pace that is likely to (complete the task) and still maintain adequate physical reserve to engage the enemy.

- **Certain**: [Top 10% Soldiers]
- **Very Likely**:
- **Likely**: [Mid-level Soldiers]
- **Unlikely**:
- **Very Unlikely**: [Bottom 5% of Soldiers]

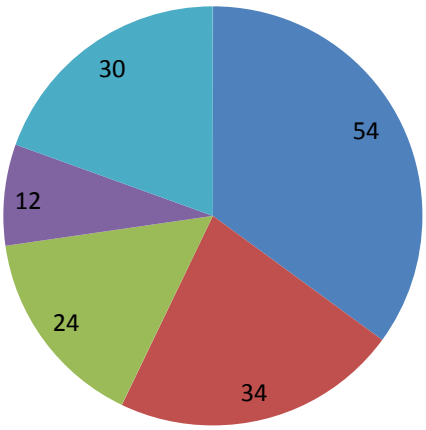
Foot March*



Move Under Fire*



Casualty Drag*

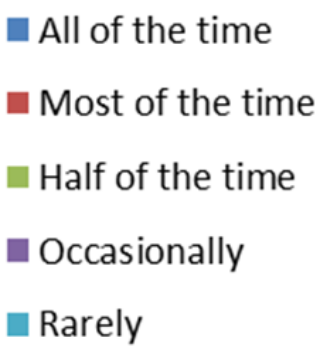


*Data includes the 19D and female Soldiers
Note: The 19D were observed by different SMEs than 19K due to separate data collection locations

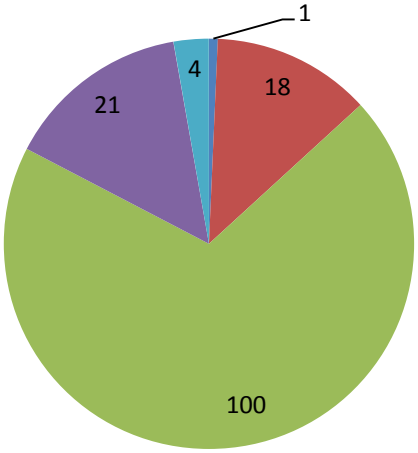
19D Tasks: Ability

This Soldier is performing this task with technique that will (complete the task) and does not risk injury to themselves.

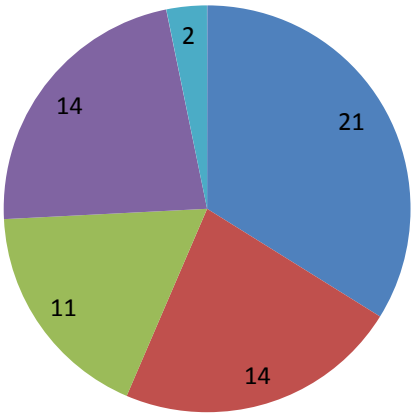
- **All of the task**
- **Most of the time**
- **Half of the time**
- **Occasionally**
- **Rarely**



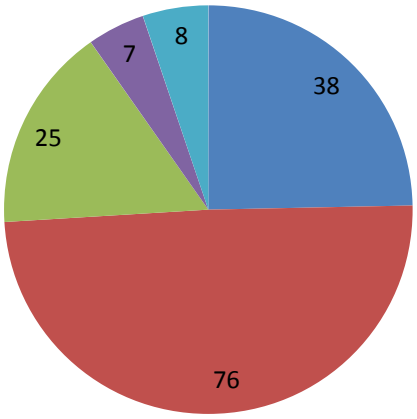
Foot March*



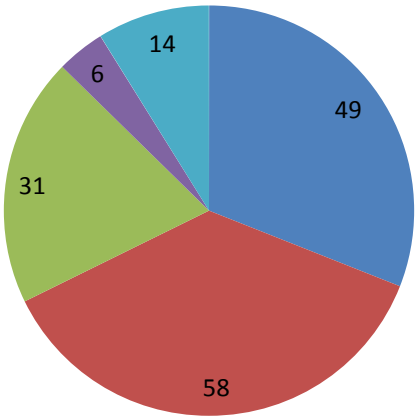
Casualty Evacuation[1]*



Casualty Drag*



Move Under Fire*



*Data includes the 19D and female Soldiers

[1]Not all Soldiers were observed due to lack of SMEs present

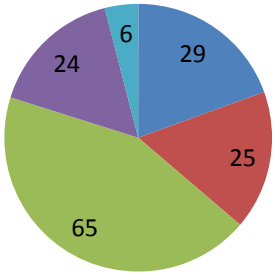
Note: The 19D were observed by different SMEs than 19K due to separate data collection locations

19K Tasks: Pace

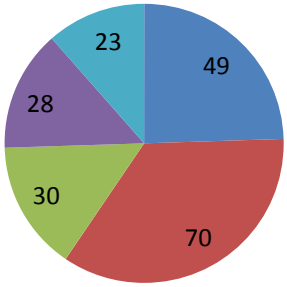
This Soldier is performing this task at a pace that is likely to (complete the task) and still maintain adequate physical reserve to engage the enemy.

- **Certain**: [Top 10% Soldiers]
- **Very Likely**:
- **Likely**: [Mid-level Soldiers]
- **Unlikely**:
- **Very Unlikely**: [Bottom 5% of Soldiers]

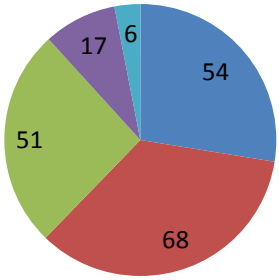
Foot March*



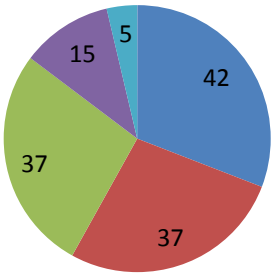
Casualty Drag*



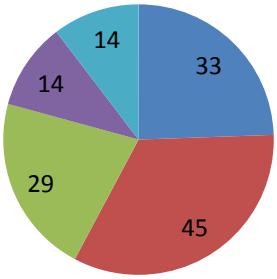
Move Under Fire*



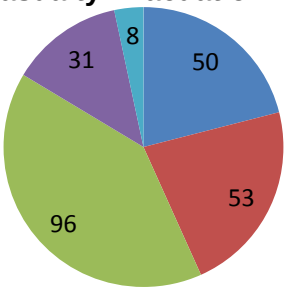
Load Main Gun*



Stow Ammo*



Casualty Evacuation*



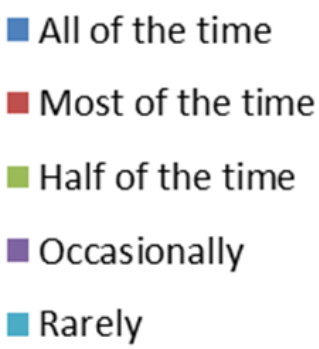
*Data includes the 19K and female Soldiers

Note: The 19K were observed by two different sets of SMEs (as well as a different set than the 19K) due to separate data collection locations

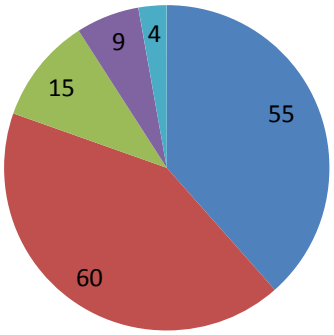
19K Tasks: Ability

This Soldier is performing this task with technique that will (complete the task) and does not risk injury to themselves.

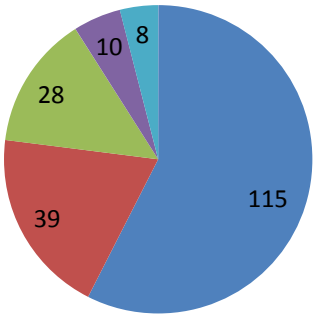
- **All of the task**
- **Most of the time**
- **Half of the time**
- **Occasionally**
- **Rarely**



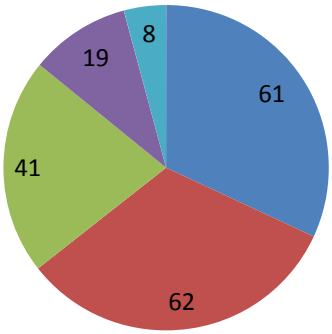
Foot March*



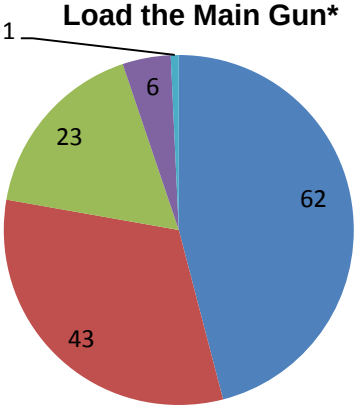
Casualty Drag*



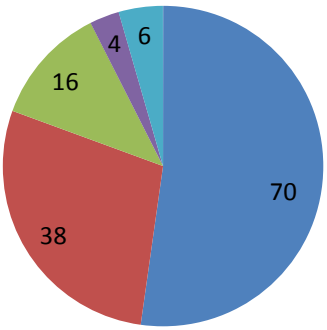
Move Under Fire*



Load the Main Gun*



Stow Ammo*



*Data includes the 19K and female Soldiers

Note: The 19K were observed by two different sets of SMEs (as well as a different set than the 19K) due to separate data collection locations