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As part of a TRADOC directed initiative to develop physical performance standards for all Army military occupational specialties (MOS's), a series of databases of the physically demanding tasks of MOS's has been developed. The purpose of this paper is to describe the creation of databases compiling the physically demanding tasks of Army MOS's and to provide some preliminary analyses of the databases. These results can be used for research purposes to model Army jobs, to prepare MOS specific physical training programs, to identify the jobs and equipment most in need of redesign, and to develop physical performance standards. The six task categories developed into databases were: 1) lifting and carrying, 2) lifting and lowering, 3) climbing, 4) digging, 5) walking, marching and running, and 6) pushing and pulling. The databases provide the first searchable source of information on the physical demands of Army MOS's. This report provides summary information, however, many more questions may be answered using these databases. Copies of the databases (SPSS 6.0) are available upon request and are importable into standard spreadsheet programs. For disk or e-mail copies, please contact the authors at:

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A DATABASE OF PHYSICALLY DEMANDING TASKS PERFORMED BY U.S. ARMY SOLDIERS

by
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FOREWARD

Since the late 1970's, the Department of the Army has considered the development of occupationally-related physical standards for use in the selection and assignment of soldiers to military occupational specialities (MOS) to better match soldier physical capability to physical job requirements. In 1977, the U.S. Army Research Institute of Environmental Medicine was tasked to develop a system for establishing such job-related standards (Vogel, Wright and Patton et al, 1980) as well as a test battery to screen new accessions for MOS classification (Sharp, Wright, Vogel et al, 1980). These efforts, however, were never implemented due to the perceived negative impact on such personnel issues as recruitment, ability to fill heavy or very heavy lifting jobs and the potential exclusion of women from entering some of the more physically demanding MOS's.

In 1985, a second effort was made to develop a screening procedure for use in selecting individuals for MOS's prior to entry into basic training (Teves, Wright, and Vogel, 1985). This procedure, the Military Enlistment Physical Strength Capacity Test or MEPSCAT, was implemented on a trial basis but was never made mandatory or validated and was discontinued in 1993 due to its expected adverse effects on recruitment.

The U.S. Army Training and Doctrine Command (TRADOC), in 1994, decided to re-look at the possibility of developing physical performance standards for all Army MOS's. The impetus for establishing a new program was the continuing concern that, with no physical qualification standards or screening mechanism in place, new accessions (recruits) would enlist for an Army occupation regardless of whether or not they have the physical capability of meeting the physical requirements of the job. It was perceived that large mismatches could occur between a soldier's capability and the physical demands of his/her selected occupation. Such mismatches could jeopardize unit performance, increase the risk for injury and decrease overall morale. The Deputy Chief of Staff for Training, TRADOC, requested that USARIEM develop a

plan to ensure that all soldiers would be capable of performing the physically demanding tasks of their selected MOS's.

A two-tiered approach was devised by Dr. James A Vogel, Director, Occupational Health and Performance Directorate, USARIEM, and briefed by him to the Training and Doctrine Command (TRADOC), the Deputy Chief Staff for Personnel (DCSPER), and the Assistant Secretary of the Army for Manpower and Reserve Affairs (ASA-M&RA) in 1995. In this approach, soldiers would first undergo a screening procedure at the Military Entrance Processing Station to determine their potential of meeting the physical demands of their respective MOS. Secondly, at the end of Advanced Individual Training, they would be required to meet a performance standard based on the actual requirements of the most physically demanding MOS tasks (Patton and Sharp, 1997).

In the development of the MOS standards portion of this two-pronged approach, it is first necessary to identify all of the physically demanding tasks and the individual requirements that comprise each of the MOS's. This report presents a database of the physical tasks found within each of the six physical job categories (i.e., lifting/lowering, lift and carry, climbing, digging, walking/marching, and pushing/pulling) that make up all enlisted military occupational specialities.

ACKNOWLEDGMENT

This project was initiated by Dr. James A. Vogel, while serving as Director, Occupational Health and Performance Directorate, at the U.S. Army Research Institute of Environmental Medicine. It was his vision that led to this report. The Army Training and Doctrine Command (TRADOC) encouraged and supported USARIEM in this undertaking. A special thank you goes to MAJ Bobbie McQueen, TRADOC, who was instrumental in providing points of contact for information gathering. MAJ McQueen sought out knowledgeable subject matter experts for each career management field or proponent school. The subject matter experts willingly gave their time to provide accurate, detailed information essential to the compilation of the databases.

EXECUTIVE SUMMARY

As part of a TRADOC directed initiative to develop physical performance standards for all Army military occupational specialties (MOS's), a series of databases of the physically demanding tasks of these MOS's have been developed. The impetus for this was the development of physical performance standards: 1) to screen new recruits for physically demanding MOS's, and 2) to establish physical competency at the end of Advanced Individual Training or One-Station Unit Training. While the physical standards project has been delayed due to political concerns, the completed databases are useful for the development of physical training programs and to the military research community.

The physical requirements of all MOS's are available in Army Regulation 611-201 (AR 611-201); however, it is difficult to make generalizations from this document. There is currently no electronic means to access information, nor are statistics available regarding the physical demands of Army MOS's. The purpose of this paper is to describe the creation of a series of databases compiling the physically demanding tasks of Army MOS's and to provide some preliminary analyses of the databases. These results can be used for research purposes to model Army jobs, to prepare MOS specific physical training programs, to identify the jobs and equipment most in need of redesign, and to develop physical performance standards.

The six task categories developed into databases were: 1) lifting and carrying, 2) lifting and lowering, 3) climbing, 4) digging, 5) walking, marching and running, and 6) pushing and pulling. The most common physically demanding task is lifting and carrying (232 tasks), followed by lifting and lowering (92 tasks). The climbing, digging and walking/marching/running databases contained relatively few tasks.

The median loads lifted and distances carried by soldiers far exceed those reported in the literature for civilian occupations. Many of the lift and carry tasks involve teamwork (49%), as did the majority of lifting and lowering tasks (53%).

The average loads that must be lifted and carried individually and in two-person teams are comparable to the loads soldiers self-select as the maximum they are able to lift and carry. The loads soldiers are required to lift and lower to perform Army tasks appear to be within the capabilities of soldiers tested in our laboratory (Sharp, et al, 1997).

The databases provide a searchable source of information on the physical demands of Army MOS's. This report provides summary information; however, many additional questions may be answered using these databases. Copies of the databases (SPSS 6.0) will be made available upon request and are importable into standard spreadsheet programs. For disk or e-mail copies, please contact the authors at: U.S. Army Research Institute of Environmental Medicine

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INTRODUCTION

In recent years, the U.S. Army has been increasingly concerned regarding the capability of its fighting force to perform the physically demanding tasks required to meet mission requirements during combat (Personal Communication MG Ernst, DCST, TRADOC, 1994; Government Accounting Office 1976; 1996). It has been perceived that significant mismatches occur between the physical abilities of soldiers and physical job requirements. While the frequency of such mismatches has not been well documented, three sources of information have suggested that such problems may exist: 1) a 1994 survey by the Army Research Institute for the Behavioral Sciences, Alexandria, VA of selected military occupational specialities, found that only 33-38% of women and 53-68% of men, depending on the job, reported no difficulty in lifting objects in MOS's classified as "heavy" or "very heavy" with respect to their lifting requirements (Brady and Rumsey,1990), 2) anecdotal reports from field commanders during recent U.S. Army deployments, e.g. Desert Shield/Desert Storm, Somalia, Haiti, (Personal Communication, General Stroup, ODCSPER, 1994) that soldiers of both genders occasionally were incapable of performing some of the physical tasks of their jobs, and 3) the reported large differences between male and female soldiers in physiological capacities and physical performance (Sharp, 1994; Sharp and Vogel 1992) which may translate to differences in ability to perform physically demanding tasks.

While some of the gap between an incoming recruit's physical capacity and the physical requirements of the job can be narrowed by physical training, large gaps can not be overcome by such training. The time allotted for physical training during the basic and advanced individual training cycles of U.S. Army training is unlikely to increase aerobic capacity more than 10-15% (Vogel, Patton, Mello, and Daniels, 1985) and muscular strength more than 20% (Knapik, Wright, Kowal and Vogel, 1980). It is important, therefore, to provide a system to screen recruits to reduce the likelihood of large mismatches and to ensure that soldiers can perform the physical tasks of their jobs in order to enhance overall unit performance and decrease the chance of job-related injuries.

Based on the potential for mismatching soldier capability and occupational demand, the U.S. Army has a two-fold requirement: first, to ensure that new accessions are assigned to MOS's for which they have the physical potential, allowing for some improvement in physical capability during basic training and advanced individual training; and second, to ensure that soldier's graduating from advanced individual training are capable of performing the physical tasks of the MOS's for which they were trained. To meet these requirements, this Institute proposed a two-tiered level of assessment (Patton and Sharp, 1997) to match soldier capability to job demands. The first level of assessment would take place at the Military Entrance Processing Station where recruits are in-processed prior to basic training. This assessment would consist of a screening test to provide a general measure of physical capacity to determine the potential of the soldier to meet the physical demands of the chosen MOS.

The second level test or evaluation would be conducted at the end of advanced individual training and would determine whether the soldier can perform the physical demands of the MOS. This test would require the soldier to meet a physical standard based on the most physically demanding task(s) of the MOS. To develop these standards, it is necessary to identify the physical task requirements for all of the Army military occupational specialities. Such information can be found in Army Regulation 611-201 (Headquarters, Department of the Army, 1995).

The purpose of this report is to describe the development of a series of databases from this Army regulation which can be used to provide easy access to information regarding the physical demands of Army jobs. The primary use of such information would be to develop the physical performance standards for groups of MOS's with similar physical demands. Other uses could be to identify MOS's most in need of task redesign, to provide a basis for the development of task specific physical training programs, and to design and develop appropriate screening tests for assessing physical task performance.

METHODS

AR 611-201

Army Regulation 611-201 provides the enlisted MOS classification structure for the U.S. Army. As part of this structure, the regulation includes a description of the physical requirements for all MOS's and classifies each MOS into one of five physical demands categories based on the lifting requirements of that MOS. These physical demands categories are listed in Table 1 and represent a modified Department of Labor (DOL) classification scheme (Office of the Deputy Chief of Staff for Personnel, 1982). While AR 611-201 lists all the physically demanding tasks of each MOS (i.e., lifting and carrying, digging, climbing, pushing/pulling, marching, or lifting only tasks), the physical demand rating that is assigned to an MOS from Table 1 is based solely on the weight and frequency of the lifting demands, with no reference to lifting height.

Table 1. Army Modified Department of Labor Physical Demand Classification System

	Occasional (<20% of the time)	Frequent/Constant (>20%<80%)
Light	20 lbs	10 lbs
Medium	50 lbs	25 lbs
Moderately Heavy	80 lbs	40 lbs
Heavy	100 lbs	50 lbs
Very Heavy	>100 lbs	>50 lbs

UPDATE OF AR 611-201

The physical requirements for each MOS are updated on an as-needed basis and a new regulation is published approximately every two years. To request changes in an MOS, DA Form 5643-R, found in AR 611-201, is

completed by the proponent school for that MOS and submitted through channels to the DCSPER. A copy of DA Form 5643-R is in Appendix A.

For the present update, TRADOC organized a teleconference with subject matter experts (SME's) from each of the 17 proponent schools (e.g., armor, artillery, infantry, quartermaster, military police, medical, transportation, ordnance, engineer, chemical). These SME's were instructed to review the physical requirements listed in AR 611-201 for their respective MOS's and to revise them to reflect any recent changes in equipment involved, unit staffing and mission requirements, and the tactical situation which could result in changes in task performance. DA Form 5643-R was used by the schools for this update because school personnel were already familiar with it. Illustrative examples of the necessary level of detail were provided to each school by TRADOC. All revisions received were annotated in AR 611-201. (See Appendix H for quality of the update response.)

DA Form 5643-R was also used to verify the information in AR 611-201. If a task listed in the regulation could not be matched with a DA Form 5643-R, the validity of this task was questioned. To further clarify the tasks of each MOS, follow-up questions were directed to SME's from each proponent school.

DATABASE DEVELOPMENT

Once all information was received from the proponent schools and AR 611-201 appropriately updated, separate databases were constructed for each physical task category found in the regulation. These were: lifting/lowering, lifting and carrying, pushing/pulling, climbing, digging, and walking/marching/running. All databases included the following information: MOS number, MOS nomenclature, career management field, physical demand category (from Table 1), and whether or not the MOS was open to women. The following fields were included as appropriate to the database: total load (lifted, carried, shoveled, packed, etc) in lbs, team size (one or more), load handled per person in lbs, distance moved in feet or miles (horizontally and/or vertically), rate of movement, torque applied, volume dug and frequency of task performance. Vertical

distances were categorized as follows: few inches to two feet, two feet to waist height, above waist to shoulder height and above shoulder to full reach. Rate of movement was categorized as walk/march, run or sprint. Although AR 611-201 does not distinguish between frequent and constant, the data collection form (DA 5643) does. This information was recorded when DA 5643 was available for a task. Therefore, task frequency was rated as occasional (less than 20% of the time), frequent (more than 20%, but less than 80% of the time) or constant (more than 80% of the time).

The most demanding task for each task category was selected for each MOS. If a MOS had multiple tasks from a given category the most demanding task at each frequency was entered into the database. In addition, if a MOS had both team and individual tasks within a task category, the most physically demanding team and individual tasks at each frequency were included. Therefore, a single MOS could be represented by multiple tasks within a single database. For example, if a MOS had a frequent lift and carry task, an occasional team lift and carry task and an occasional individual lift and carry task listed in AR 611-201, all three would be listed in the database. Descriptive statistics for each database are presented and broken down by task frequency, team size and physical demand category, as appropriate.

RESULTS

LIFTING AND CARRYING DATABASE

The lifting and carrying database contains 232 lift and carry tasks performed by 172 different MOS's. Two lift and carry tasks were included for 47 MOS's, three tasks were included for three MOS's, one MOS had four tasks, and one had five. Figure 1 is a frequency distribution of carry distance in 25 foot increments. A tabular frequency distribution for the distances carried can be found in Appendix B (Table 6) of this report. The majority of lift and carry tasks (52%) involve carries of 30 feet or less. Eighty-four percent of the loads are carried 50 feet or less, while only 6.6% of the loads are carried more than 100 feet. The shortest carry reported was two feet and the longest 300 feet. It should be noted that loads carried 400 feet or more and mobility tasks with no load were placed in the walk/run/march database (p. 15).

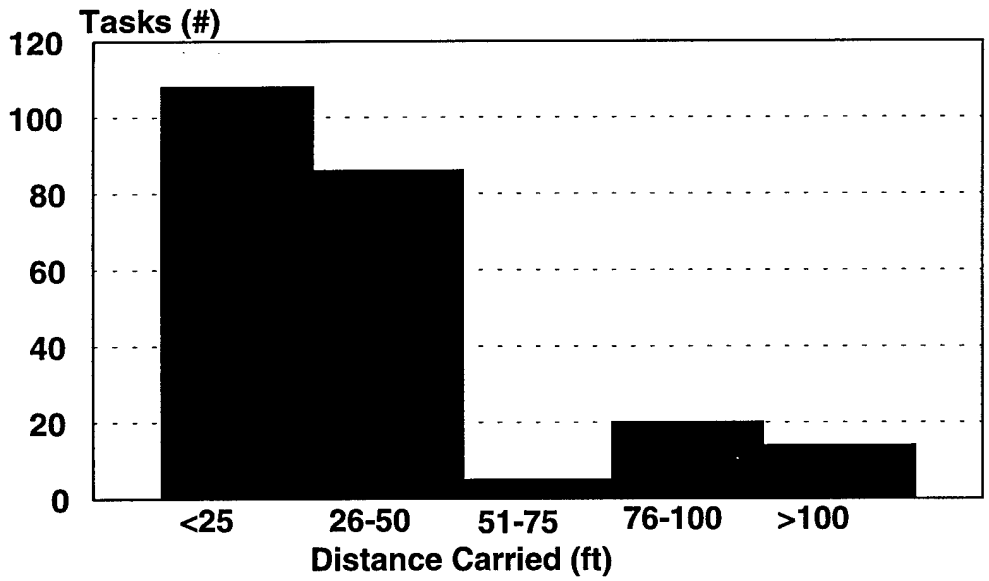

Figure 1. Frequency distribution of distance carried (ft).

Figure 2 is a frequency distribution of the loads carried, which ranged from 10 to 187.5 lbs/person. This information can be found in tabular form in Table 7 of Appendix B. The 25th, 50th and 75th percentile loads were 50 lbs, 66 lbs, and 88 lbs, respectively. Loads in excess of 100 lbs ("very heavy" physical demand category for occasional lifting) comprised 11% of the tasks (n=26). These "very heavy" loads were carried an average distance of 37 feet (range=3-150 feet), with 58% of "very heavy" loads carried 25 feet or less. There was no relationship (r=-0.02, p=0.74) between the weight of the load carried and the distance it was carried. A scatterplot of the load by distance carried is shown in Figure 3.

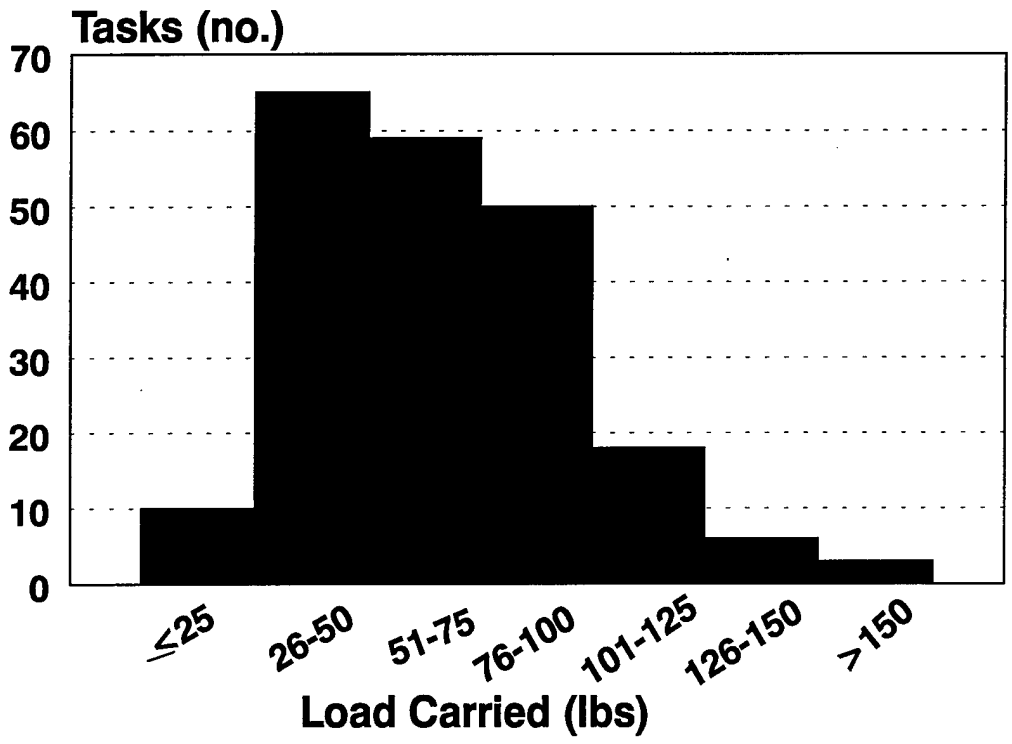

Figure 2. Frequency distribution of loads carried (lbs).

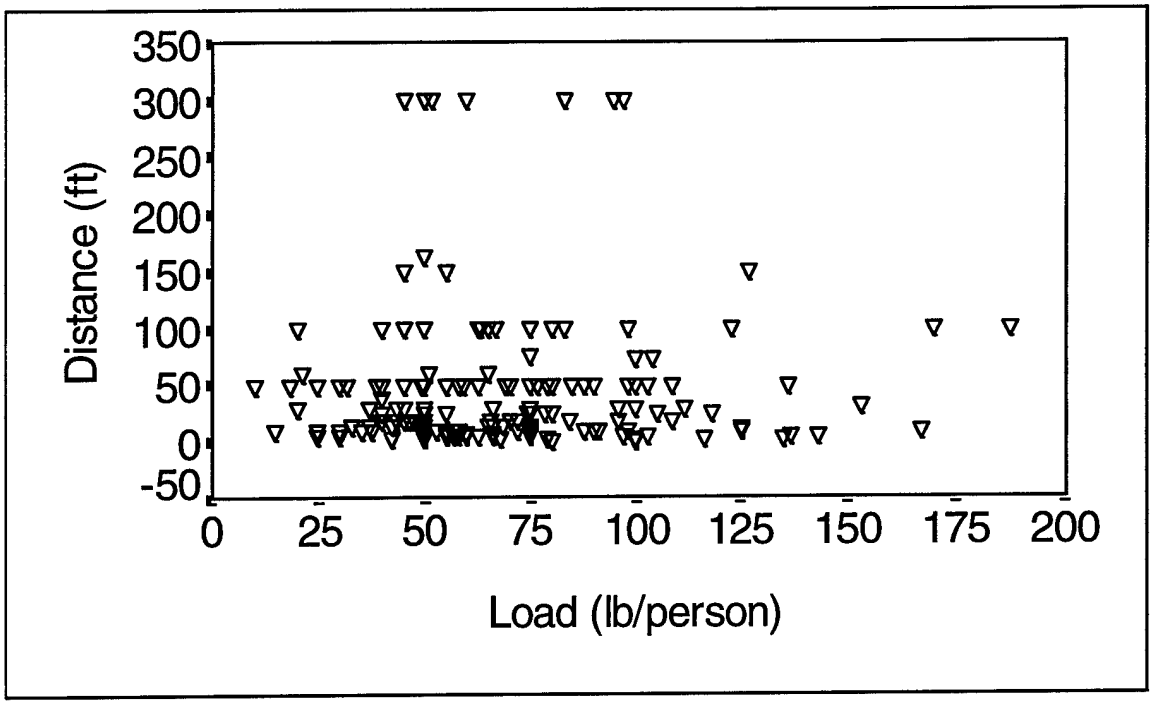

Figure 3. Scatterplot of load (lbs/person) by distance carried (ft) for 232 lift and carry tasks.

The distribution of lifting height for lifting and carrying tasks (n=232) is shown in Figure 4.

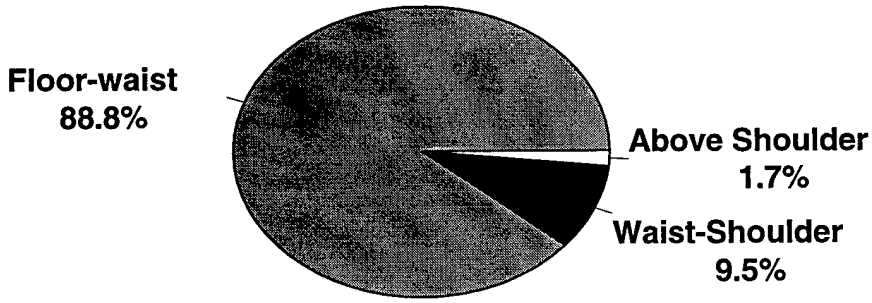

Figure 4. Distribution of lifting height for lifting and carrying tasks.

Fifty one percent of lift and carry tasks were individual tasks, 26% were two person tasks, 7% were three-person tasks and 13% were four-person tasks. The remaining tasks (3%) involved more than four people. The median load (lbs/person) and distance lifted and carried by one, two, three and four person teams was 67 lbs and 50 ft, 63 lbs and 20 ft, 90 lbs and 15 ft, and 88 lbs and 30 ft, respectively. The mean load and distance carried by frequency of task performance are shown in Figure 5. There was no statistical difference in the load ($p=0.49$) or distance carried ($p=0.58$) due to the frequency of task performance. The majority of the lift and carry tasks (61%) were performed on an occasional basis, while 38% were performed frequently.

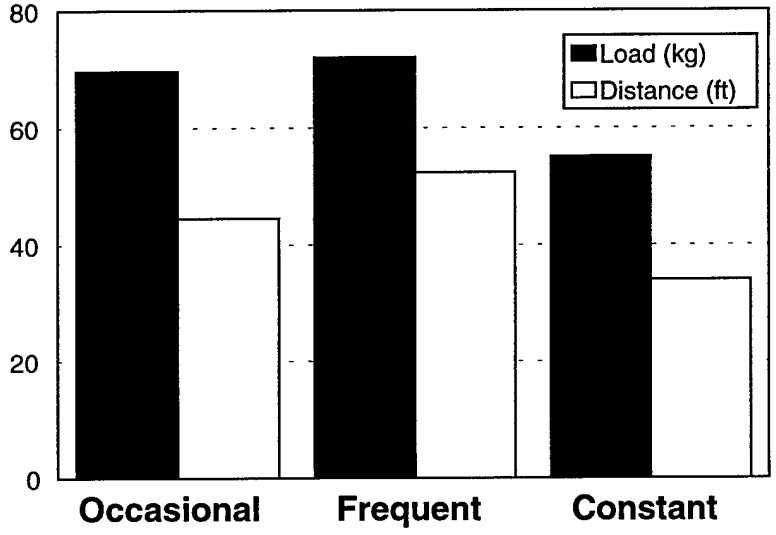

Figure 5. Mean load (lbs) and distance (ft) of lift and carry tasks by task frequency.

Table 2 lists the mean load and distance carried for each of the physical demand categories. As expected, the load carried increased with an increase in the rating of the physical demand category. The mean load for the "very heavy"

category was heavier than all other categories ($p<0.05$) and the "heavy" category load was greater than the "light" or "medium" category loads ($p<0.05$). There are tasks within each physical demand category that exceed the category weight limit (excluding the "very heavy" category). Similarly, there are tasks within each physical demand category that are below the range specified for that category (excluding the light category). The distance carried by category was much more variable than the load. While a difference was found in the distance carried across physical demand categories via a one-way ANOVA, no significant differences between means were found using a post-hoc Tukey test.

Table 2. Load and distance (mean ± SD) carried by MOS physical demand category

Category (n)	Load (lbs/person)	Distance (ft)
Light (7)	31.7 ± 15.7	111.4 ± 129.8
range, median	10-50, 32	10-300, 50
Medium (30)	46.8 ± 13.9	34.4 ± 56.5
range, median	18-66, 50	3-300, 10
Mod. Heavy (43)	56.0 ± 17.2	46.9 ± 53.0
range, median	20-90, 55	2-300, 25
Heavy (36)	65.0 ± 23.2	52.7 ± 68.9
range, median	10-100, 67	2-300, 50
Very Heavy (116)	85.7 ± 29.8	45.2 ± 51.5
range, median	30-188, 80	3-300, 50

LIFTING/LOWERING DATABASE

The 92 lifting/lowering tasks in the database represent 75 different MOS's. Fifteen MOS's had two lifting/lowering tasks, while one MOS had three tasks. The mean load for all tasks was 78.0 ± 37.4 lbs. The 25th, 50th, and 75th percentile loads calculated were 50 lbs, 75 lbs, and 107.5 lbs. respectively.

Twenty-six percent of the tasks were in the "very heavy" lifting category (>100 lbs). A tabular frequency distribution of the loads lifted/lowered is in Appendix C (Table 8). The majority of the tasks (61%) were performed occasionally, 35% were performed frequently and 4% (4 tasks) were performed constantly.

Sixty-eight percent of the loads were lifted to waist height or below, 27% were lifted between waist and shoulder height, and only 4.3% were lifted above shoulder height. A tabular frequency distribution for lifting/lowering height is in Appendix C (Table 9). The mean load lifted to each vertical distance was: 97.1 ± 30.0 lbs to one foot (n=27), 74.9 ± 41.7 lbs to waist height (n=36), 62.0 ± 29.8 lbs to shoulder height (n=25), and 78.0 ± 41.5 lbs above shoulder height (n=4).

The loads lifted by MOS physical demand category are listed in Table 3. The one task in the "light" category is for a Broadcast Journalist (46R) in which a camera head assembly is lifted onto a pneumatic pedestal. This task was in the updated information and was not listed in AR 611-201. This MOS is rated "light" in AR 611-201; however, the updated task indicates the MOS should be rated "very heavy". As with the lifting and carrying database, there are tasks above and below the stipulated weight range for most physical demand categories.

Table 3. Load lifted by physical demand category for lifting and lowering database.

Physical Demand Category (n)	Mean ± SD	Median	Range
Light (1)	154		
Medium (5)	38.8 ± 12.7	45.0	35-50
Mod. Heavy (23)	56.7 ± 17.5	58.0	33-80
Heavy (16)	68.0 ± 22.7	66.0	30-110
Very Heavy (47)	94.5 ± 40.1	93.0	32-237

Forty-seven percent of lifting tasks were individual tasks, 42.4% were two-person team tasks, 3.3% were three-person team tasks, 6.5% were four-person team tasks and one task was a six-person team lift. The mean loads lifted by team size were 73 lbs for one person (n=43), 85 lbs/person for two people (n=39), 63 lbs/person for three people (n=3) and 68 lbs/person for four people (n=6).

CLIMBING DATABASE

Climbing was not a frequently occurring physical requirement with only 19 tasks listed from 19 different MOS's. A frequency distribution of equipment used during climbing, the climbing height and the load carried while climbing can be found in Appendix D (Tables 10, 11 and 12). A ladder was the most frequently used climbing apparatus (11 of 19 tasks). Five tasks did not specify the type of equipment used. Of the remaining three tasks, Infantrymen (11B) climb ropes to 30 ft, Cable Systems Installer/Maintainers (31L) climb poles and trees to 40 ft, and Petroleum Supply Specialists (77F) climb petroleum tower stairs to 50 ft. Climbing height ranged from nine to 200 ft with a mean of 27 ft and a median of 12 ft. The 25th, 50th and 75th percentile values were 10 ft, 12 ft and 24 ft, respectively. Only one task required soldiers to climb more than 50 ft. This was for MOS 33Y, Strategic Systems Repair, where soldiers climb antenna superstructures 50-200 ft tall. In thirteen of nineteen tasks, no load is carried while climbing. Loads for the remaining six tasks averaged 60.8 ± 27.8 lbs (range= 25 lbs to 95 lbs).

DIGGING DATABASE

The digging database contains 18 tasks, representing 18 different MOS's. The reported shovel loads ranged from 10 lbs (six tasks) to 33 lbs (one task), with an average of 18.2 ± 6.6 lbs. The volume of material dug ranged from 3 cu ft to 183 cu ft, with a mean volume of 48.9 ± 45.5 cu ft. Frequency distributions of shovel load and volume dug are available in Appendix E (Tables 13 and 14). Soldiers with the greatest digging requirement are Laundry and Shower Specialists (57E) who dig trenches 1 x 1 x 183 feet long to emplace pipe.

WALKING/MARCHING/RUNNING DATABASE

The walking/marching/running database contains 22 tasks from 18 different MOS's. Four MOS's have two tasks. A frequency distribution for the distance traveled during walking/marching/running tasks is in Appendix F (Table 15). The distance traveled varies from 0.03 mi (150 ft) to 25 mi, with a mean distance of 8.3 ± 8.7 mi. The 0.03 mi task (13 M, Multiple Launch Rocket System Crewmember) did not involve a load, so it was placed in the walking/marching/running database. The majority of tasks (17 of 22) involved distances of 8 miles or less and 23% (5 tasks) involve distances of less than one mile. Infantry MOS's accounted for all three 25 mile loaded marching tasks. A frequency distribution of loads carried is in Appendix F (Table 16). These loads ranged from none (0 lbs, 24% of the tasks) to 65 lbs with a mean load of 28.7 ± 23.0 lbs. The speed was characterized as walk/march, run, sprint or a combination of these categories. A frequency distribution of movement speed is in Appendix F (Table 17). Fifteen tasks (68%) were walk/march, two tasks were running, one task was sprinting and four were a combination.

PUSHING/PULLING DATABASE

The pushing/pulling database contains 81 tasks from 77 different MOS's. Four MOS's had two pushing/pulling tasks. The loads pushed/pulled ranged from 25 to 525 lbs, with an average load of 131.9 lbs and a median load of 82 lbs. A frequency distribution of these loads is included in Appendix G (Table 18). Nearly all tasks over 150 lbs involved pushing an item on wheels or a wheeled cart. One exception was the Chemical Defense Specialist (54B) who manually moves fog oil in 55 gallon drums weighing 237 lbs in the back of a 2-1/2 ton truck.

As listed in Appendix G (Table 19), the distance objects are pushed/pulled ranged from 0.5 to 600 feet. The average distance pushed/pulled was 33.6 ft, and the median distance was 4 ft. Seventy-four percent or 58 of the

push/pull tasks were performed with no mechanical assistance. Carts or wheeled transports were used for 19% or 15 of the tasks. Four tasks involve reeling/unreeling rope or cable, and one task was done using a conveyor. Three of the tasks did not specify the type of equipment available. The majority of tasks were individual tasks (51% or 41 tasks). Thirty-four percent (27 tasks) were two-person, six were three-person, five were four-person, and one involved six people. The mean load and distance objects were pushed/pulled is listed by physical demand category in Table 4.

Since the use of materials handling aids (i.e. wheels, carts, etc) would greatly affect task difficulty, the 58 tasks performed manually were analyzed separately. As listed in Appendix G (Table 20), the loads ranged from 25-500 lbs, with an average load of 91 lbs and a median load of 78 lbs. As listed in Appendix G (Table 21), the distance objects were manually pushed/pulled ranged from 0.5 to 600 ft, with an average of 29 ft and a median of 3 ft.

Table 4. Load (lbs/person) and distance (ft) of push/pull tasks by physical demand category (Mean ± SD, (range)).

Category (# of tasks)	Load (lbs/person)	Distance (ft)
Light (1)	202.0	15
Medium (14)	111.9 ± 136.4 (25-525)	9.8 ± 14.9 (1.5-50)
Mod. Heavy (14)	97.3 ± 102.7 (33-400)	25.0 ± 34.7 (1-100)
Heavy (13)	102.5 ± 121.8 (40-500)	34.9 ± 57.7 (0.5-200)
Very Heavy (39)	159.5 ± 142.8 (30-525)	45.1 ± 112.5 (1-600)

DISCUSSION

The lifting and carrying database had the greatest number of tasks, followed by the lifting and lowering database. The climbing, digging and walking/marching/running databases contained relatively few entries. These findings are similar to those reported for the British Army, where the most commonly occurring physically demanding tasks involved lifting and lifting and carrying (Rayson, 1997). Although there were few entries in the walking/marching/running database, long distance road marching with a loaded backpack is an important physical task. Considerable research and training effort is currently directed toward improving load carriage performance (Obusek and Bensel, 1997; Harman, et al., 1998). The Infantry Career Management Field makes up a large percentage of total Army personnel (approximately 13.6% of E4 and below) while containing only four entry level MOS's. Infantry soldiering tasks accounted for the heaviest loads and the longest distances carried.

The distance Army soldiers must carry loads is considerably longer than industrial requirements. Drury , Law and Pawenski (1982) reported the median distance for industrial carries to be 5 feet whereas the mean was 25 feet for military lift and carry tasks. The U.S. Army tasks were similar to those performed by the British Army. Rayson (1997) reported that 59% of the loads were carried less than 33 feet. It should be noted that military tasks are often performed in a field setting where conditions may preclude the use of vehicles or other materials handling aids. Because distances may change with the work environment, they should be considered best estimates from subject matter experts.

The median load lifted in an industrial setting has been reported to be 20 lbs (Drury,et al, 1982) compared to a median lift of 66 lbs for military lift and carry tasks and 75 lbs for lifting/lowering tasks. By definition, the most physically demanding tasks (i.e. heaviest loads) were selected for inclusion in the database; therefore, it is difficult to make a valid comparison with the data of Drury et al. (1982). In a study of self-selected loads for lifting and carrying boxes 24 ft at the rate of 1 time per minute, Sharp et al. (1995) reported that male soldiers select an average load of 79 lbs for lifting and carrying, while

women select an average load of 52 lbs. The one repetition maximum lift and carry strength for women is 78.3 lbs (Sharp et al, 1995), which is only slightly greater than the average load for Army lifting and carrying tasks (70 lbs). Based on this data, average male soldiers would be working at their self-selected maximum load when performing the average Army lifting and carrying tasks. The average female soldier tested would probably be unable to repetitively lift and carry a 70 lb load, since this is only slightly less than her one repetition maximum load for lifting and carrying.

Forty eight percent of the lift and carry tasks and 53% of the lifting/lowering tasks involved teamwork. Rayson (1997) reports the British Army uses teamwork for 63% of the physically demanding tasks. As seen in Figure 6, the average load for a two-person lifting and carrying task is 129 lbs. This is similar to the mean load of 131 lbs selected by teams of two-soldiers during a

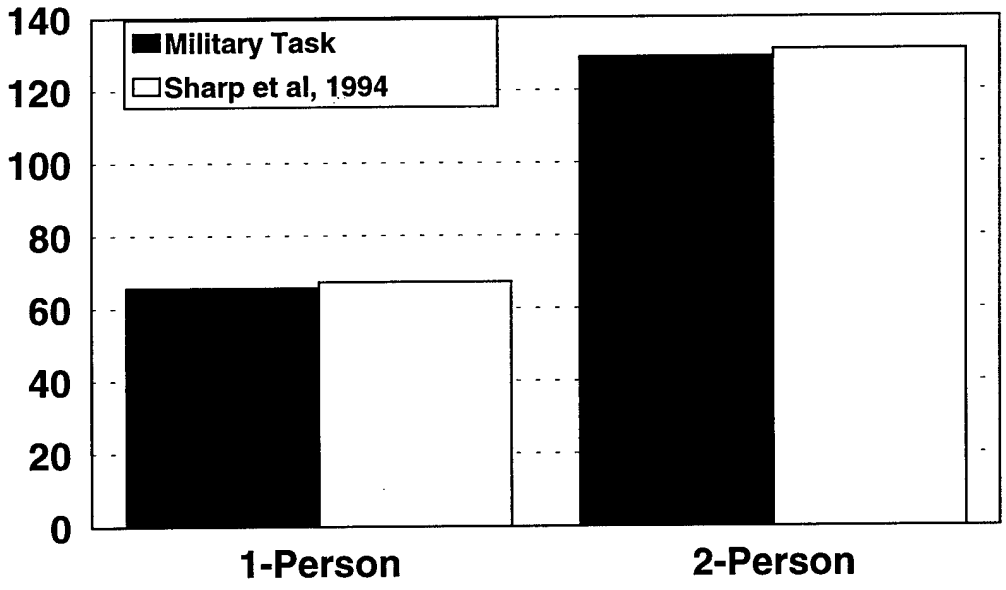

Figure 6. Mean load (lbs) for Army lifting and carrying tasks vs soldier selected maximum acceptable load (lbs).

recent study of the maximum acceptable load for repetitive lifting and carrying (Sharp, et al. 1995). The gender specific data from this study revealed that teams of two men select a load of 158 lbs, teams of two women select a load of 101 lbs (17% less than the standard Army two-person lift and carry task), and mixed gender teams (one man and one woman) select a load of 125 lbs. As these gender specific figures represent the mean of the soldiers studied, there are teams within all three gender groups that would experience difficulty with the median Army two-person lift and carry task.

In Table 5 the team lifting task loads are listed with the 1-RM load lifted by teams of two to four women. The third column shows the task requirement as a percentage of the maximum load lifted by teams of women (task load/women team load x 100) . The loads lifted to knuckle height were lifted under optimum conditions using a device similar to a weight lifting bar (Sharp, 1997). These loads represent the absolute maximum that could be lifted by teams of women. As teams of all-women tended to have lower maximum lifting strength than mixed-gender or all-men teams, the percentage would be expected to be lower (easier to lift) for all-men and mixed-gender teams. Doolittle, et al. (1988) recommend that an individual not lift more than 20% of his/her maximum for repetitive efforts, and not more than 75% for occasional efforts. None of the

Table 5. Comparison of MOS team lifting requirements to women's team lifting capacity (Sharp et al., 1997).

Team Size (persons)	Task Requirement (lbs)	Teams of Women (lbs)	Percentage of Women's Maximum (%)
One	73	186	39
Two	170	343	50
Three	126	472	27
Four	136	677	20

loads in Table 5 appear to be too great to be lifted occasionally to knuckle height.

Figure 7 illustrates the mean load carried by physical demand category (bars) and the occasional and frequent category limits (lines). Several MOS's had lift and carry tasks or lifting/lowering tasks that either exceeded or fell short of the weight range for that physical demand category. There are several potential reasons for this mis-match. It will be recalled that the physical demand category was taken directly from AR 611-201, but that many of the tasks were from updated information. Therefore, the loads may have increased since the last publication of AR 611-201. The reverse situation undoubtedly occurred as well. The updated information indicated that loads had decreased, but the published tasks and physical demand category assigned to that MOS did not

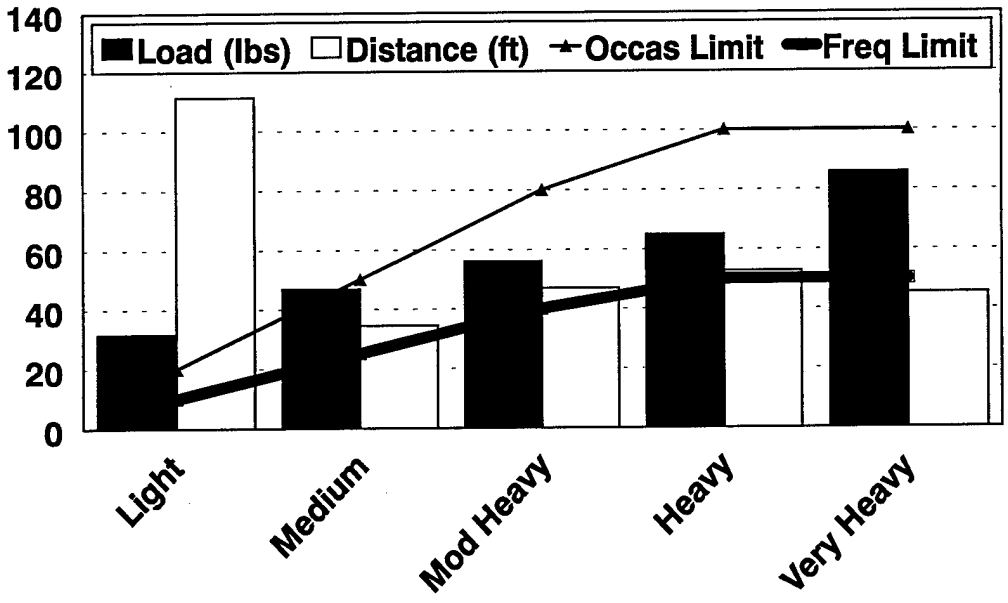

Figure 7. Load and distance carried for each physical demand category (bars). Lines represent occasional and frequent load limits.

reflect this change. A second possibility is that the physical demand category assignment was based on a different task, since multiple tasks were entered for many MOS's. The determining task could have been in either the lifting/lowering database, or the lifting and carrying database. A third possibility is that the MOS may not have been properly classified.

To briefly examine the issue of MOS misclassification, the updated physical demands were compared to the current physical demand category rating for each MOS. The results were recorded as one of the following: correctly classified, tasks too heavy for category based on AR 611-201, tasks too light for category based on AR 611-201, tasks too heavy for category based on updated information, tasks too light for category based on updated information. Seventy-six percent of the MOS's were correctly classified. Nearly 10% (19 MOS's) had a mismatch between the physical demands and category assignment as they appeared in AR 611-201. Of these, eight had tasks that exceeded the physical demands category, while eleven MOS's had tasks that were below the weight range of the assigned category. An additional 25 MOS's (13%) were misclassified due to the updated information. Of these, 14 MOS's now had tasks that exceeded the physical demands of the assigned physical demand category, while 11 MOS's had lower physical demands than specified by the assigned category. Misclassification due to updated information is acceptable assuming the updated information will be incorporated into AR 611-201. A subjective assessment of the responses to our request for updating AR 611-201 can be found in Appendix H.

The mismatch between published standards and category assignment is not easily explained. In one instance (38A, Civil Affairs Specialist) the physical demand category rating was "heavy" in 1994 with tasks that supported a "medium" rating and was increased to "very heavy" in the 1995 version of AR 611-201, with no change in the physical requirements list.

The information contained in these databases will need to be updated periodically as tasks change due to equipment changes, changes in standard operating procedures for task performance and when MOS's are deleted,

merged or added. The databases represent a convenient means to examine the range of MOS physical demands in terms of frequency of task performance and task intensity.

CONCLUSIONS

1. The majority of physically demanding tasks involve lifting and carrying or lifting and lowering.

2. Teamwork is involved in many of the physically demanding tasks. More data is needed to determine what percentage of Army personnel are capable of performing these tasks.

3. Many inconsistencies were found between the physical demand category of an MOS and the essential tasks of that MOS.

RECOMMENDATIONS

1. A three-pronged approach should be taken to improve the match between soldier physical capacity and the physical demands of the MOS: 1) reduce the loads soldiers are required to lift through ergonomic re-design; 2) increase the lifting capacity of the soldier through well designed physical training programs; 3) implement a physical selection process for the most demanding MOS's.

2. The acceptability of representative, physically demanding, individual and team tasks should be determined in large populations of soldiers to provide information on the physical readiness.

3. A mandatory updating system and accompanying training procedures are necessary to ensure the physical demand ratings and tasks lists in AR 611-201 are accurate.

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APPENDIX A

Sample Department of the Army Form 5643

M TAB TAB

PHYSICAL DEMANDS ANALYSIS WORKSHEET

For use of this form, see AR 611-1; the proponent agency is DCSPER

PAGE OF PAGES

MOS CMF DATE COMPLETED *(YYMMDD)*

SECTION I - DUTIES

SECTION II - TASK SUMMARY

SECTION III - CRITICAL TASK ELEMENT	SECTION IV - CRITICAL PERFORMANCE MEASURE

SECTION V - ANALYSIS

FACTOR	WEIGHT/ LOAD	HORIZ. DISTANCE	VERTICAL DISTANCE	WORK RATE/PERFORMANCE STANDARD	MOS FREQ			
a	*b*	*c*	*d*	*e*	NP	O	F	C
1. LIFT/LOWER								
2. CARRY								
3. PUSH								
4. PULL								
5. LOAD BEAR								
6. WALK/MARCH								
7. CLIMB/ DESCEND								
8. RUN/RUSH								
9. SWIM/DIVE								
10. DIG								
11. CRAWL								
12. THROW								

M

FACTOR	WEIGHT/ LOAD	HORIZ. DISTANCE	VERTICAL DISTANCE	WORK RATE/PERFORMANCE STANDARD	MOD FREQ			
a	b	c	d	e	f			
					NP	O	F	C
13. HANDLE								
14. FINGER								
15. HAMMER/ POUND								
16. SIT								
17. RECLINE								
18. REACH								
19. STAND								
20. STOOP								
21. KNEEL								
22. CROUCH								

SECTION VI - EXPLANATION/COMMENT - PHYSICAL DEMAND FACTORS

SECTION VII - (PHYSICAL DEMANDS RATING) FOR USE BY APPROVING AUTHORITY

___ LIGHT ___ MEDIUM ___ MOD. HEAVY ___ HEAVY ___ VERY HEAVY

EXPLANATION AND SPECIFIC INSTRUCTIONS FOR COMPLETION OF WORKSHEET ARE CONTAINED IN WOMEN IN THE ARMY POLICY REVIEW, ODCSPER, DA, 12 NOV 82.

APPENDIX B

Table 6. Frequency distribution of carry distance (ft) for lift and carry tasks.

Carry Distance (ft)	Number of Tasks	Percent of Tasks	Cumulative Percent of Tasks
2	2	.9	.9
3	4	1.7	2.6
4	4	1.7	4.3
5	11	4.7	9.1
6	10	4.3	13.4
8	1	.4	13.8
9	8	3.4	17.2
10	26	11.2	28.4
12	2	.9	29.3
15	10	4.3	33.6
20	19	8.2	41.8
25	11	4.7	46.6
30	12	5.2	51.7
33	1	.4	52.2
40	1	.4	52.6
50	72	31.0	83.6
60	3	1.3	84.9
75	2	.9	85.8
76	1	.4	86.2
100	19	8.2	94.4
150	3	1.3	95.7
164	1	.4	96.1
300	9	3.9	100.0
Total	232	100.0	100.0

Table 7. Frequency distribution, percentage (%) and cumulative percentage (cum %) for load carried (lbs/person) during lift and carry tasks.

Load (lbs)	Tasks (#)	%	Cum %	Load (lbs)	Tasks (#)	%	Cum %	Load (lbs)	Tasks (#)	%	Cum %
10.0	2	1	1	57.0	2	1	39	88.0	2	1	75
15.0	1	0	1	58.0	3	1	40	90.0	5	2	77
18.5	1	0	2	59.0	1	0	41	91.5	1	0	78
20.0	3	1	3	60.0	3	1	42	95.0	1	0	78
21.0	1	0	3	62.5	5	2	44	96.0	2	1	79
25.0	4	2	5	63.0	1	0	44	97.0	2	1	80
30.0	4	2	7	65.0	4	2	46	98.0	5	2	82
32.0	1	0	7	65.5	1	0	47	100.0	16	7	89
33.0	1	0	8	66.0	9	4	50	103.0	2	1	90
35.0	1	0	8	67.0	1	0	51	104.0	1	0	90
37.0	2	1	9	68.0	1	0	51	105.0	1	0	91
37.5	1	0	9	68.3	1	0	52	109.0	4	2	92
39.0	1	0	10	70.0	14	6	58	116.2	1	0	93
42.0	2	1	13	72.0	2	1	59	118.0	2	1	94
43.5	2	1	14	74.5	1	0	59	122.5	1	0	94
45.0	9	4	18	75.0	18	8	67	125.0	2	1	95
46.5	1	0	18	76.5	1	0	68	127.0	1	0	96
47.5	1	0	19	78.5	1	0	68	135.0	1	0	96
48.5	1	0	19	79.0	2	1	69	136.0	1	0	97
49.0	3	1	20	80.0	5	2	71	137.0	3	1	98
50.0	32	14	34	83.2	1	0	72	143.0	1	0	98
51.0	1	0	34	83.3	1	0	72	153.0	1	0	99
51.5	1	0	35	84.0	1	0	72	167.0	1	0	99
52.5	1	0	35	85.0	3	1	74	170.0	1	0	100
55.0	6	3	38	87.5	1	0	74	187.5	1	0	100

APPENDIX C

Table 8. Frequency distribution for load (lbs/person) lifted or lowered.

Load (lbs)	Tasks (#)	%	Cum %
25.0	2	2.2	2.2
30.0	1	1.1	3.3
32.0	2	2.2	5.4
33.0	1	1.1	6.5
35.0	2	2.2	8.7
40.0	4	4.3	13.0
41.0	1	1.1	14.1
42.0	1	1.1	15.2
42.5	1	1.1	16.3
43.0	1	1.1	17.4
45.0	1	1.1	18.5
48.3	1	1.1	19.6
49.0	1	1.1	20.7
50.0	10	10.9	31.5
56.0	1	1.1	32.6
58.0	1	1.1	33.7
60.0	2	2.2	35.9
62.0	3	3.3	39.1
63.0	1	1.1	40.2
65.0	3	3.3	43.5
67.5	1	1.1	44.6
69.0	2	2.2	46.7
70.0	2	2.2	48.9

Load (lbs)	Tasks (#)	%	Cum %
75.0	9	9.8	58.7
80.0	5	5.4	64.1
82.0	1	1.1	65.2
83.3	1	1.1	66.3
87.5	2	2.2	68.5
89.0	1	1.1	69.6
92.5	1	1.1	70.7
93.0	1	1.1	71.7
100.0	2	2.2	73.9
103.0	1	1.1	75.0
109.0	7	7.6	82.6
110.0	5	5.4	88.0
115.0	1	1.1	89.1
117.0	1	1.1	90.2
117.5	1	1.1	91.3
125.0	2	2.2	93.5
130.0	1	1.1	94.6
141.0	1	1.1	95.7
154.0	1	1.1	96.7
171.0	1	1.1	97.8
200.0	1	1.1	98.9
237.0	1	1.1	100.0
Total	92	100.0	

Table 9. Frequency distribution of vertical distance for lifting or lowering.

Lift/lower Height	Tasks (#)	Percent	Cumulative Percent
ground to 2 ft	27	29.3	29.3
2 ft to waist	36	39.1	68.5
waist to shoulder	25	27.2	95.7
above shoulder	4	4.3	100.0
Total	92	100	

APPENDIX D

Table 10. Frequency distribution of apparatus used for climbing tasks.

Apparatus	Tasks (#)	Percent	Cumulative Percent
not specified	5	26.3	26.3
stairs/ramp	1	5.3	31.6
ladder/tower	11	57.9	89.5
rope	1	5.3	94.7
poles/trees	1	5.3	100.0
Total	19	100.0	

Table 11. Frequency distribution of climbing height (ft).

Climbing Height (ft)	Tasks (#)	Percent	Cumulative Percent
9	3	15.8	15.8
10	4	21.1	36.8
11	1	5.3	42.1
12	3	15.8	57.9
15	2	10.5	68.4
20	1	5.3	73.7
24	1	5.3	78.9
30	1	5.3	84.2
40	1	5.3	89.5
50	1	5.3	94.7
200	1	5.3	100.0
Total	19	100.0	

Table 12. Frequency distribution of load carried (lbs) while climbing.

Climbing Load (kg)	Tasks (#)	Percent	Cumulative Percent
0	13	68.4	68.4
25	1	5.3	73.7
40	1	5.3	78.9
50	1	5.3	84.2
65	1	5.3	89.5
90	1	5.3	94.7
95	1	5.3	100.0
Total	19	100.0	

APPENDIX E

Table 13. Frequency distribution of shovel load (lbs/shovel) during digging tasks.

Shovel Load (lbs)	Tasks (#)	Percent of Tasks	Cumulative Percent
10	6	33.3	33.3
20	1	5.6	38.9
21	9	50.0	88.9
25	1	5.6	94.4
33	1	5.6	100.0
Total	18	100.0	

Table 14. Frequency distribution of volume moved (cu. ft.) during digging tasks.

Volume Dug (cu. ft.)	Tasks (#)	Percent of Tasks	Cumulative Percent
3	2	11.1	11.1
24	1	5.6	16.7
36	11	61.1	77.8
54	1	5.6	83.3
67	1	5.6	88.9
150	1	5.6	94.4
183	1	5.6	100.0
Total	18	100.0	

APPENDIX F

Table 15. Frequency distribution of distance (mi) for walking/marching/running tasks.

Distance (mi)	Tasks (#)	Percent of Tasks	Cumulative Percent
0.03	2	9.1	9.1
0.25	2	9.1	18.2
0.60	1	4.5	22.7
2.00	3	13.6	36.4
3.00	1	4.5	40.9
5.00	1	4.5	45.5
6.00	2	9.1	54.5
8.00	5	22.7	77.3
20.00	2	9.1	86.4
25.00	3	13.6	100.0
Total	22	100.0	

Table 16. Load carried or pack load (lbs) while walking/marching/running.

Load (lbs)	Tasks (#)	Percent	Cumulative Percent
0	5	22.7	22.7
10	1	4.5	27.3
15	1	4.5	31.8
20	2	9.1	40.9
25	2	9.1	50.0
26	3	13.6	63.6
40	1	4.5	68.2
41	1	4.5	72.7
45	1	4.5	77.3
57	1	4.5	81.8
60	1	4.5	86.4
65	3	13.6	100.0
Total	22	100.0	

Table 17. Frequency distribution of speed of walking/marching/running.

Movement Speed	Tasks (#)	Percent	Cumulative Percent
walk/march	15	68.2	68.2
run	2	9.1	77.3
sprint	1	4.5	81.8
All of above	4	18.2	100.0
Total	22	100.0	

APPENDIX G

Table 18. Frequency distribution of loads (lbs/person) pushed or pulled.

Load (lbs)	Tasks (#)	%	Cum %
25.0	1	1.2	1.2
30.0	3	3.7	4.9
33.0	1	1.2	6.2
35.0	2	2.5	8.6
37.0	1	1.2	9.9
40.0	1	1.2	11.1
42.5	1	1.2	12.3
43.5	1	1.2	13.6
45.0	2	2.5	16.0
49.0	2	2.5	18.5
50.0	7	8.6	27.2
60.0	2	2.5	29.6
62.0	1	1.2	30.9
62.5	1	1.2	32.1
63.0	1	1.2	33.3
63.3	1	1.2	34.6
65.0	2	2.5	37.0
66.0	1	1.2	38.3
70.0	2	2.5	40.7
75.0	1	1.2	42.0
80.0	2	2.5	44.4
82.0	7	8.6	53.1
83.0	1	1.2	54.3
87.0	1	1.2	55.6
90.0	2	2.5	58.0
94.0	1	1.2	59.3
100.0	10	12.3	71.6
102.0	1	1.2	72.8
116.2	1	1.2	74.1
120.0	1	1.2	75.3
130.0	1	1.2	76.5
150.0	2	2.5	79.0
175.0	1	1.2	80.2
200.0	1	1.2	81.5
202.0	1	1.2	82.7
237.0	1	1.2	84.0
250.0	2	2.5	86.4
265.0	1	1.2	87.7
300.0	2	2.5	90.1
400.0	1	1.2	91.4
405.0	1	1.2	92.6
500.0	4	4.9	97.5
525.0	2	2.5	100.0
Total	81	100.0	

Table 19. Frequency distribution of distance (ft) objects are pushed or pulled.

Distance(ft)	Tasks (#)	% of Tasks	Cumulative Percent
0.5	2	2.5	2.5
1.0	3	3.7	6.2
1.5	2	2.5	8.6
2.0	12	14.8	23.5
3.0	18	22.2	45.7
4.0	6	7.4	53.1
5.0	8	9.9	63.0
6.0	1	1.2	64.2
8.0	1	1.2	65.4
10.0	1	1.2	66.7
15.0	3	3.7	70.4
20.0	3	3.7	74.1
25.0	3	3.7	77.8
35.0	1	1.2	79.0
50.0	7	8.6	87.7
80.0	1	1.2	88.9
100.0	4	4.9	93.8
150.0	1	1.2	95.1
200.0	1	1.2	96.3
250.0	1	1.2	97.5
300.0	1	1.2	98.8
600.0	1	1.2	100.0
Total	81	100.0	

Table 20. Frequency distribution of loads (lbs/person) pushed or pulled using no mechanical aids (i.e. wheels, carts).

Load (lbs)	Tasks (#)	%	Cum %
25.0	1	1.7	1.7
30.0	3	5.2	6.9
33.0	1	1.7	8.6
35.0	2	3.4	12.1
40.0	1	1.7	13.8
42.5	1	1.7	15.5
45.0	2	3.4	19.0
49.0	2	3.4	22.4
50.0	6	10.3	32.8
60.0	2	3.4	36.2
62.0	1	1.7	37.9
62.5	1	1.7	39.7
63.3	1	1.7	41.4
65.0	1	1.7	43.1
66.0	1	1.7	44.8
70.0	2	3.4	48.3
75.0	1	1.7	50.0

Load (lbs)	Tasks (#)	%	Cum %
80.0	2	3.4	53.4
82.0	7	12.1	65.5
83.0	1	1.7	67.2
90.0	2	3.4	70.7
94.0	1	1.7	72.4
100.0	6	10.3	82.8
102.0	1	1.7	84.5
116.2	1	1.7	86.2
130.0	1	1.7	87.9
150.0	2	3.4	91.4
200.0	1	1.7	93.1
237.0	1	1.7	94.8
250.0	1	1.7	96.6
300.0	1	1.7	98.3
500.0	1	1.7	100.0
Total	58	100.0	

Table 21. Frequency distribution of distance (ft) objects are pushed or pulled using no mechanical aids (i.e. wheels, carts).

Distance (ft)	Tasks (#)	Percent	Cum Percent
0.5	2	3.4	3.4
1.0	3	5.2	8.6
1.5	2	3.4	12.1
2.0	11	19.0	31.0
3.0	16	27.6	58.6
4.0	6	10.3	69.0
5.0	4	6.9	75.9
6.0	1	1.7	77.6
8.0	1	1.7	79.3
10.0	1	1.7	81.0
20.0	1	1.7	82.8
25.0	3	5.2	87.9
35.0	1	1.7	89.7
50.0	1	1.7	91.4
80.0	1	1.7	93.1
150.0	1	1.7	94.8
200.0	1	1.7	96.6
300.0	1	1.7	98.3
600.0	1	1.7	100.0
Total	58	100.0	

APPENDIX H

UPDATE RESPONSE QUALITY

The type and initial quality of the updated information received from each school was recorded. The type of response was classified as DA Form 5643-R, a letter, or telephonic. The quality of the response was then subjectively rated as inadequate, adequate, or superior, depending on the amount of follow-up required to clarify or verify the physical demands of the MOS.

Of the approximately 209 MOS's in the Army, proponent schools for 85 MOS's (44%) responded to the update request by letter, with nearly half (49%) being of superior quality. Responses containing both an explanatory letter and DA Form 5643 tended to be of superior (13 of 14 responses) or adequate quality (1 of 14 responses), with all the DA Form 5643 forms dated 1994. The proponent schools for nearly one-fourth of the MOS's (49) responded by mailing the DA Form 5643s or form 932s (older version DA Form 5643). These tended to be of poor quality (55%) due to the age of forms and the lack of selection or review. The dates of the forms ranged from 1984 to 1994 with a median date of 1988. Twenty-five percent of the forms were dated 1984, 68% were dated pre-1990 and 29% appeared to have been completed in response to the update request and were dated 1994. During follow-up questioning it was occasionally revealed that the piece of equipment specified on an older DA form 5643 was no longer in use, or that the forms for the more critical tasks had not been included in the mailing. Forty-five percent of these responses did not contain enough information to adequately define the tasks of the MOS in question. One proponent school (5 MOS's) telephonically stated that no changes were needed and there were 44 MOS's (22.3%) for which no response was received. Although the initial response to the update request was disappointing, follow up contact proved to be much more effective in clarifying the tasks. The majority of SME's were both helpful and knowledgeable.