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THE POTENTIAL FOR RESTRUCTURING MOS TASKS TO REDUCE PHYSICAL DEMAND REQUIREMENTS OF CRITICAL MOS

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Requiring physical strength standards for military occupational specialties (MOS) also requiring high aptitude could lead to shortages in some critical skills for the Army. Ten soldiers from each of five MOS that would probably be required to meet strength standards were interviewed to determine what physically demanding tasks they had experienced and what changes could be made to reduce these demands. Two of the MOS were jobs where the physically demanding taks were encountered in the field. Sharing the task or reassigning it to a stronger person would reduce the requirements. Two other MOS were jobs where the physically

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) demanding tasks were encountered in the workshop. Job aids and correct lifting procedures would reduce the physical demand in these cases. The fifth MOS, medical specialist, had very demanding tasks that could only be reduced by assigning these to another MOS. Originator supplied keywords included

THE POTENTIAL FOR RESTRUCTURING MOS TASKS TO REDUCE PHYSICAL DEMAND REQUIREMENTS FOR CRITICAL MOS

Foreword

The Fort Hood Field Unit of the US Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research in a variety of areas related to the needs of the Army in the field. This report addresses one such area, personnel selection and assignment. It deals specifically with what the impact of adopting physical fitness standards would be on personnel availability.

The Army Research Institute for Environmental Medicine (ARIEM) has produced a set of physical fitness clusters that are used to describe the strength and stamina requirements of Army Military Occupational Specialties (MOS). These could be used to set standards for lifting strength and aerobic capacity for each MOS that would ensure that the soldiers assigned to it had sufficient strength and stamina to carry out all the physical tasks required by their job.

This study found that the number of soldiers who would have to meet these standards would be so large that personnel shortfalls in many MOS would result. The biggest impact would occur in those MOS that also have high aptitude requirements. These physical fitness requirements need to be examined on a job-by-job basis to determine whether changes could be made to reduce them. The feasibility of doing this was tested with five MOS and reduction in physical fitness requirements was found to be possible for four of them.

The research described in this report was performed by personnel of the Human Resources Research Organization (HumRRO), under Contract No. MDA903-79-C-0191. This research is responsive to the objectives of RDTE Project 2Q263743A794, "Human Factors and Training Research in Military Organizations and Systems," FY 1981 Work Program.

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THE POTENTIAL FOR RESTRUCTURING MOS TASKS TO REDUCE PHYSICAL DEMAND REQUIREMENTS FOR CRITICAL MOS

Executive Summary

Requirement:

The Army, along with the other armed services, has been considering the use of MOS-specific physical demands standards as a basis for screening personnel prior to Military Occupational Specialty (MOS) assignment. These standards would ensure that the soldiers assigned to a specific MOS would have sufficient strength and stamina to accomplish all of the tasks in that MOS. Development of specific standards and identification of what the standards for each should be is being done by the US Army Research Institute of Environmental Medicine (ARIEM).

In the first year report from the current US Army Research Institute for Behavioral and Social Sciences (ARI) project ("The Impact of Adopting Physical Fitness Standards on Army Personnel Assignment: A Preliminary Study," by Marston, Kubala, and Kraemer) evidence was presented that a system based on ARIEM physical fitness clusters would create Army-wide personnel assignment problems in that the number of high aptitude personnel qualified for critical skill MOS would be reduced even further than at present. This ARI report proposed that MOS with both high aptitude and high physical demand requirements be examined carefully to determine whether modifications could be made in specific tasks which would reduce the physical demands requirements.

Procedure:

Five MOS were identified for study: Radio Operator (05B), Power Generation Equipment Repairer (52D), Helicopter Repairer (67 series), Medical Specialist (91B), and Electronic Warfare/Signal Intelligence Voice Interceptor (98G). These specialties represented a broad range of combat support activities, whose incumbents had high mental aptitude as indicated by Army Forces Qualification Test (AFQT) scores, and which had strength requirements that were either high or medium.

Ten soldiers with pay grades ranging from E2 to E7, who were working in the primary duties of their MOS, were interviewed in each specialty. Since women tend to have less upper body strength than men and thus would be more affected by physically demanding tasks, as many females were included in the interviews as possible. The number of women per MOS ranged from five for 98Gs to one for 52D.

The interview was conducted at the soldier's work place whenever possible. It focused primarily on those tasks that soldiers reported were physically demanding to them. A job analysis approach was used to determine the significant details of each demanding task and to collect any other available data relating to physical demands, including data on fatigue, strains and suggested job modifications. The physical skill and coordination aspects of the job were also examined.

Findings:

Forty-eight of the 50 soldiers reported at least one task in his/her MOS to be physically demanding. The mean number ranged from 1.7 tasks for the 67 series to 2.4 tasks for 05B. The females reported a mean of 2.4 tasks compared to the males who reported 2.0 tasks. There was a tendency for the number of tasks reported to increase with age, but this was significant only for males ($r = .29$). There was no significant relationship for the number of physically difficult tasks with time in service, with height, or with weight. Analysis of the tasks was done by grouping them into major categories of general or MOS-specific tasks and into seven minor task categories. The categories of tasks reported fell into patterns according to the type of job. The technical specialists who worked in the field reported primarily general tasks such as erecting tents while the maintenance personnel reported primarily tasks specific to their MOS such as removing head bolts. The medical specialist did not fit well in either group.

Those soldiers working in shops generally found ways to reduce the physically demanding aspects of their jobs. Hoists or other tools were used to lift heavy parts while carts were used to move heavy equipment. There was a sharp contrast between the two groups of technical specialists who worked in the field. The 98Gs cooperated with each other and worked together in carrying out the more physically demanding tasks. The 05Bs, however, reported that it was difficult to get assistance in moving heavy equipment and complained that many soldiers in the MOS were not doing their part. So far as 91B is concerned, the main physically difficult task, litter bearing, can be extremely strenuous as can be the erection of tents, erection of camouflage nets and changing ambulance and truck tires. What needs to be examined further, however, is the requirement that medical specialists (i.e., the 91 MOS series) be required to do such heavy lifting. Other soldiers who do not have such high aptitude levels and extensive training requirements could just as easily be assigned to the medical company in lieu of some of the medical personnel; they could be pressed into service to carry litters, perform other heavy work and perform guard duty.

Utilization of Findings:

The number of soldiers who meet both physical and aptitude standards for many critical MOS is limited. If the proposed clustering criteria are adopted as ARIEM physical fitness standards, there will be an even greater shortage than at present of soldiers in the critical high aptitude MOS.

By following the approaches suggested in this ongoing ARI research to restructure MOS tasks (by transferring physically demanding tasks to other soldiers and/or by developing job aids), it is proposed that a three-fold benefit will accrue: (1) the number of high aptitude MOS requiring high standards of physical fitness will be reduced, (2) the total number of soldiers required for high aptitude MOS will also be reduced, and (3) since the most physically demanding tasks will be eliminated from high aptitude MOS, more soldiers will be physically qualified and available for assignment to those MOS having: (a) "high aptitude only" requirements, and (b) both high aptitude and high physical standard requirements.

At a time when the Armed Forces are facing a decreasing manpower pool, the proposed concept will effectively increase the amount of manpower available for critical

MOS while simultaneously reducing the number of personnel required for these critical MOS. This has particularly important implications regarding the utilization of female soldiers. Modifying jobs to reduce physical demands would have other benefits in addition to increasing the number of people available for assignment. A direct benefit would be a reduction of on-the-job injuries currently resulting from excessive lifting. This would represent significant savings to the Army in terms of both dollars and manpower because it would increase the number of days soldiers are at work and it would reduce medical and disability costs. Carrying out this approach would mean that only those MOS that really require high physical fitness standards would use such standards.

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Introduction and Literature Review

Background

The military is faced with personnel selection and job assignment problems very different from those encountered in industry. While it is true that many Army jobs have civilian counterparts, these are not always performed in comparable situations. During the heat of battle, soldiers may be required to work for longer hours, under more severe time stresses and in harsher environments than civilian workers. This means that even for jobs with titles similar to civilian ones, the physical requirements must be higher for the military than for the general work force. Recognition of this has led the Army to develop various methods to ensure that its soldiers are physically fit for the work they may have to do in wartime. A key element to ensure this is the physical fitness training program. It starts when the new recruits first arrive for basic training and continues throughout their career in the form of regular long distance runs and calisthentics. Periodic PT (physical training) tests are used to monitor compliance. Less well known, perhaps, but equally important to ensure soldiers are physically capable are the procedures employed to select only the most able soldiers for those jobs where strength or stamina is an essential requirement. In the past, this was done on the basis of a physician's judgment made as a part of the required medical examination. Now, the Army has instituted research projects to develop a more objective way of assessing physical fitness.

The previous report from this project[1] examined what the impact on personnel selection and assignment would be if the physical fitness clustering criteria presented by the US Army Research Institute of Environmental Medicine (ARIEM) were used as standards.[2,3] Under such a system each Military Occupational Specialty (MOS) would be open only to those who met the appropriate physical fitness standards. The ARIEM clusters were defined by the amount of strength and stamina required to accomplish the most strenuous tasks in a cluster of physically similar MOS. These clusters ranged from

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[1]P. T. Marston, A. L. Kubala, & A. J. Kraemer. The impact of adopting physical fitness standards on Army personnel assignment: A preliminary study (Final Report FR-MTRD(TX)-80-6). Alexandria, VA: Human Resources Research Organization, March 1980 (rev. February 1981).

[2]J. A. Vogel, J. E. Wright, & J. F. Patton, III. Development of new gender-free physical fitness standards for the Army, Proceedings of the 1980 Army Science Conference, West Point, NY, June 1980.

[3]J. A. Vogel, J. E. Wright, J. F. Patton, III, J. Dawson, & M. P. Eschenback. A system for establishing occupationally-related gender-free physical fitness standards (USARIEM T-5/80). Natick, MS: US Army Research Institute of Environmental Medicine, April 1980.

Alpha, which required soldiers with both high strength and high stamina, to Echo, which required only low strength and low stamina of the soldiers. The requirements for the Echo cluster were basically those required of a soldier to get through basic training and, therefore, defined the baseline standard. To avoid confusion through the remainder of this report, strength or stamina standards will refer to criteria based only upon a single dimension, while physical fitness standards will refer to criteria based upon a combination of the two.

Marston, et al.[4] reviewed the research on strength and stamina testing and used it in conjunction with personnel information on each MOS to determine the impact of using the ARIEM physical fitness clusters as standards. The existing research indicated that most soldiers would be able to meet the high stamina standard. The developer of these clusters would probably agree with this conclusion since he has co-authored a report stating that "(with)...a regimen of running for 20-25 minutes at least three times per week as a minimum...all individuals should be able to meet the minimum fitness requirements for most MOS in the Army."[5]

Since this report is concerned with the selection impact of the potential physical fitness standards and how this might be reduced, only the strength standards are considered further, since they are the only ones which would cause a meaningful reduction in the proportion of soldiers available for assignment to MOS with high physical demands. The ARIEM clusters have a high, medium, and low criterion for strength.[6] According to a table in their report, the lifts are to be made to "waist height." The standards are: "less than 30 kg (66 lb.) for the low standard, 30-40 kg (66-88 lb.) for the medium standard, and greater than 40 kg (88 lb.) for the high standard."[7] The proposed test, however, would be to exert an "isometric upright pull at 38 cm (15 in.)"[8] which would be converted to lifting capacity using a regression equation. An example of such an equation is given,[9] but the associated test[10] indicates the prediction is for the ability to lift to a height of 132 cm (52 in.). Whatever the test, it is clear that the proportion of soldiers meeting a standard would vary depending on the height of the lift required. Since height of lift was not available when the first report[11] was written, the authors assumed it would be the height of an Army truckbed, 137 cm (4.5 ft.). These estimates indicated that adoption of the

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[4]Marston, et al., op cit.

[5]W. L. Daniels, J. A. Vogel, & D. M. Kowal. Guidelines for aerobic fitness training in the US Army (ARIEM T-5/79). Natick, MS: US Army Research Institute for Environmental Medicine, August 1979, p 31.

[6]Vogel, Wright, & Patton, op. cit.

[7]Ibid, p 5.

[8]Ibid, p 8.

[9]Ibid, p. 10.

[10]Ibid, p 11.

[11]Marston, et al., op cit.

strength standards could lead to a situation where only 15 percent of all male soldiers would meet the high strength standard and possibly 80 percent would meet the medium standard.[12] On the other hand, Army personnel records indicate that 55 percent of all personnel would be assigned to MOS with a high strength standard and 76 percent would be assigned to MOS with at least a medium strength standard. Thus, even if other selection requirements are ignored, there would be just barely enough soldiers for the MOS having a medium strength standard and there would be considerable shortfall of persons for MOS with a high strength standard.

Adding a strength selection test is likely to cause the most problems for those MOS that have other stringent selection requirements such as high aptitude. Some MOS in this category are currently experiencing shortfalls in personnel that the imposition of the physical demands standards could aggravate.[13] Furthermore, imposing the physical standards across the board, without examining means of reducing them, could leave the Army vulnerable to charges of sexual discrimination since a smaller proportion of women would meet the standards because women on the average have less physical strength than men. Such standards have been held to be discriminatory unless an employer could demonstrate that the requirement was job related and that alternative ways of accomplishing the task were unsatisfactory.

If physical standards are to provide the strong soldiers for the jobs where they are needed, it will be necessary to reduce the number of positions requiring selection to a manageable size. Under the current All Volunteer Army concept, it must be assumed that the distribution of abilities in the Army's personnel pool will remain relatively fixed. Selection from this pool can provide strong soldiers for some jobs but only at the cost of reducing the number available for other jobs. If the ARIEM strength clusters were to be used as standards, then some soldiers who are not physically able to do the required tasks will have to be assigned to less essential MOS. If the number of jobs staffed this way is very large--as Marston, et al. estimate it might be--then selection alone is not an acceptable solution. This leaves the choice of either changing the soldiers to fit the jobs, or of changing the jobs to fit the soldiers. Some increase in physical abilities can be achieved with proper physical training[14] and the Army has taken steps to improve its physical fitness program.[15] However, the gains in number of people available for assignment

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[12] Personal communication from J. A. Vogel (9 February 1982) states that ARIEM conducted an unpublished study which showed that 88 percent of male and six percent of female soldiers would meet their high strength standard. The percentages for their medium strength standard are 100 percent of the males and 43 percent of the females. If this finding generalizes then the selection problem would be smaller. It would still be of concern because selection on the basis of physical fitness affects such a large proportion of MOS, including many with personnel shortages.

[13] Marston, et al., op cit.

[14] J. J. Knapik, J. E. Wright, D. M. Kowal, & J. A. Vogel. The influence of US Army basic initial entry training on the muscular strength of men and women (USARIEM M 11/80). Natick, MS: US Army Research Institute of Environmental Medicine, March 1980.

[15] Tougher, standardized PT testing adopted by Army. Army, January 1981, 56.

obtained in this way is likely to be small. An alternative is to modify the jobs to match the abilities of the soldiers. This latter approach could reduce the number of jobs requiring high strength to a number for which effective selection can be accomplished.

The primary objective of this research was to determine if the physical demand requirements for some personnel-critical MOS could be reduced. Five MOS were identified for a physical demand job analysis survey. These MOS were all support specialties that are assigned to work with combat units but do not actually engage the enemy, except under emergency conditions. The selection of MOS was based on the fact that while combat arms MOS usually have tasks that are intrinsically physically demanding, few combat arms MOS have high aptitude requirements.

Summary of Relevant Research

Our previous report reviewed the literature in the areas of strength testing, stamina testing and employee selection. It is useful at this point to expand and update that portion of the review dealing with the measurement of physical strength in order to understand the difficulty of developing a single test of strength that would be applicable to every task and thus meet legal requirements of job relatedness. This update also provides information on how the physical demands of specific tasks might be reduced.

The ability to lift heavy objects has received attention both in the military and civilian sectors. The primary concern has been the need to select personnel who can adequately perform materials handling tasks and thus reduce the incidence of job-related injuries from these tasks. The experimental approaches for assessing strength can be classified into three general approaches.[16] These are: (1) the psychophysical approach in which the individual adjusts the weight of the object until it is felt to be a "comfortable, maximum, etc.," for the lift; (2) the physiological approach in which the individual's energy consumption is monitored while engaged in heavy work; and (3) the biomechanical modeling approach in which anthropometric dimension, isometric force, mechanical advantage, and sheer forces for the individual are used in a model to predict lifting ability with a computer model.

The psychophysical approach determines maximum strength by having the individual demonstrate how much he or she can lift. It suffers from the disadvantage that (1) the results cannot be generalized to situations other than the one tested, (2) it exposes the individual to possible physical harm from overexertion, (3) the results are very sensitive to instructional effects, and (4) the method is expensive relative to the others in terms of the amount of data that has to be collected. The possibility of harm to the individual being tested makes this approach least acceptable as a screening device.

The physiological models are based on a comparison of the individual's energy expenditure rate while engaged in the task of interest with the maximum energy expenditure rate that individual can produce. Providing energy expenditure is predictably related to the load moved, it is possible to extrapolate the results of submaximal exertion to the effort exerted if the individual were working at maximal rate. The reasonableness

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[16] M. M. Ayoub, A. Mital, S. S. Asfour, & N. J. Bethea. Review evaluation, and comparison of models for predicting lifting capacity. Human Factors, 1980, 22, 257-269.

of this assumption was tested in a study in which soldiers were required to walk on a treadmill with loads of 30 to 70 kg (66 to 154 lb.).[17] These soldiers showed a constant energy expenditure per unit weight (i.e., body plus load) even when working at up to 90 percent of their maximum aerobic capacity. What is uncertain about physiological models is the problem of how to identify the kind of tasks where aerobic capacity is the limiting factor. Work that could cause injury through strain might not occur at maximum aerobic capacity. For example, lifting a 50 kg (110 lb.) weight 20 cm (7.9 in.) from the floor and lifting the same weight from the shoulder to 20 cm (7.9 in.) above the shoulder requires the same amount of energy expenditure from a strictly mechanical standpoint, but the two lifts clearly do not represent the same potential for strain.

The biomechanical models take into account both the dimensions of the body parts and the number of joints and links involved in a physical act to make predictions, but usually do not take into account the dynamic aspects of the physical act.[18] This method has the advantage of being able to use the same data to predict a number of different but related lifting acts. The current models generally do not take into account twisting, however, which can be a source of injury.[19] While the biomechanical models are useful for predicting performance on a task in general, the predictions from the current models are not accurate enough to estimate what an individual's performance would be on a specific task.

As things stand now, the results from psychophysiological studies form the basis for lifting capacity standards. To ensure safety during the screening process, ARIEM recommended lifting ability be measured with an isometric test. It was possible to identify three studies on strength that could be used to predict performance on the ARIEM test. Each of these studies: (1) used a population comparable to incoming soldiers, (2) had tasks comparable to those proposed by ARIEM, (3) used a sufficiently large enough number of individuals to get stable results, and (4) reported the findings in sufficient detail to extrapolate to the ARIEM task.

To predict what proportion of the population of soldiers could meet the ARIEM standards, it is essential to know the required height of lift. Since the studies used a variety of heights, the lifting tasks were grouped according to one of three height ranges: (1) floor-to-knuckle, (2) knuckle-to-shoulder, or (3) shoulder-to-reach, which are thought to correspond to different modes of lifting.[20] Using anthropometric data, these ranges can be defined from the male population medians as: (1) 0-76 cm (0-30 in.), (2) 76-142 cm

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[17] R. G. Soule, K. B. Pandolf, & R. F. Goldman. Energy expenditure of heavy load carriage. Ergonomics, 1978, 21, 373-381.

[18] Ayoub, et al., op cit.

[19] A new way to lift. Navy Lifeline, September 1973, 16-17.

[20] S. A. Switzer. Weight-lifting capabilities of a selected sample of human males (MRL-TDR-62-57). Wright-Patterson Air Force Base, OH: Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, June 1962.

(30-56 in.), and (3) 142-210 cm (56-83 in.), respectively.[21] The ARIEM report[22] lists three possible heights, but it is unclear which one might be the basis of the standard. The lowest lift height was 38 cm (15 in.), which is the height for the isometric test. The next was waist height, an anthropometric value not found in the tables,[23] but assumed to be about the same as elbow height for which the median is tabled at 110 cm (43.5 in.).[24] The highest lift was to the specific height of 132 cm (52 in.). The first two heights fall into lifting categories (1) and (2). The third height of 132 cm falls short of the median shoulder height for males but is above the median for females (131.8 cm (51.9 in.)) and thus could be considered as almost in the shoulder-to-reach range.

The three studies did not report their data the same way, so the percentages of those who would meet the standards had to be determined in one of two ways. For those studies where percentiles were reported, the percentage estimated as meeting the standards would correspond to the highest percentile that listed a weight equal to or greater than the standard. When only means and standard deviations of lifts were reported, the percentages meeting the standards were estimated using the normal distribution. Snook[25] reported only percentiles (i.e., 10, 25, 50, 75, and 90), while Switzer[26] reported only means and standard deviations. Emanuel, Chaffee, & Wing[27] reported both percentiles (i.e., 5, 25, 50, 75, and 95) and means and standard deviations. Table 1 summarizes the proportion of soldiers who would meet the ARIEM standards at the three lift heights. All of these studies show a decrease in the percentages when either the height of the lift or the weight of the object lifted is increased. Even with these two factors controlled by categorizing the lifts, there are large differences in the estimates of what percentages of soldiers would meet the ARIEM standards. Some of these differences may be attributable to task differences which are discussed below. In any case, all three studies predict at least a third of the soldiers would not be able to meet the high standard for knuckle-to-shoulder level lifts and that less than half would be able to meet even the medium standard in the shoulder-to-reach range.

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[21] H. P. Van Cott & R. G. Kinkade (eds.). Human engineering guide to equipment design (rev. ed.). Washington, DC: US Government Printing Office, 1972, pp 497, 512, 527.

[22] Vogel, Wright, & Patton, op cit.

[23] Van Cott & Kinkade, op cit.

[24] Van Cott & Kinkade, op cit., p 505.

[25] S. H. Snook. The design of manual handling tasks. Ergonomics, 1978, 21, 963-985.

[26] Switzer, op cit.

[27] I. Emanuel, J. W. Chaffee, & J. Wing. A study of human weight lifting capabilities for loading ammunition into the F-86H aircraft (WADC-TR-56-367). Wright-Patterson Air Force Base, OH: Wright Air Development Center, August 1956.

TABLE I

Estimated Percentage of Males Able to Meet the ARIEM Strength Standards at Knuckle, Shoulder and Reach Heights

Range	Height Lifted Begin	End (cm)	ARIEM Standard Medium	High	Study[a]
	0	46	99.9	99.0[b]	Switzer
Knuckle[d]	0	51	90	50[c]	Snook
(0-76 cm)	0	61	95	95[c]	Emanuel, et al.
	51	102	50	25	Snook
Shoulder	0	107	98.0	67.7	Switzer
(76-144)	0	122	75	25	Emanuel, et al.
	0	152	25	<5.0	Emanuel, et al.
Reach	122	153	50	25	Snook
(144-210)	0	159	44.6	2.4	Switzer

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[a] I. Emanuel, J. W. Chaffee, & J. Wing. A study of human weight lifting capabilities for loading ammunition into the F-864 aircraft (WADC-TR-56-357); S. H. Snook. The design of manual handling tasks, Ergonomics, 1978, 21, 963-985; S. A. Switzer. Weight-lifting capabilities of a selected sample of human males (MRL-TDR-62-57).

[b] Estimated from mean and standard deviation using z scores.

[c] Percentile value given in report.

[d] Ranges based on anthropometric tables in Van Cott & Kinkade, 1972, pp 497, 512, 527.

In the first study used for the estimates, Emanuel and his colleagues measured the ability of Air Force men to load ammunition boxes into a fighter aircraft.[28] The airmen lifted the boxes from the floor onto a stairstep-like series of platforms that were spaced at 30 cm (1 ft.) intervals in height. The airmen were required to use the straight-back lifting procedure. Any other method of making the lifts was disregarded. The individuals adjusted the weight of the ammunition box by adding or subtracting lead shot and notified the experimenter when it contained a "comfortable" weight which they were ready to lift. Three lifts were made to each height but only the data from the second and third lifts was used in the analysis.

A problem with the Emanuel, et al. study was the requirement that the same lifting method was used for all heights. Switzer[29] reasoned that individuals use different muscle groups depending on the height of the lift and, therefore, different body positions might be appropriate at different heights. He had male college students lift a compact sheet metal box to heights of 46 cm (18 in.), 107 cm (42 in.), and 159 cm (62.5 in.). His study had three groups based on individual's stature, but only the results for the average size group are relevant here. Despite the intent to allow variation in lifting style, the reported instructions were almost identical to those of Emanuel, et al. Switzer's medium stature group produced mean lifts that were larger than Emanuel's study at the higher lift distances and slightly smaller at the lower lifting distances.

An extensive body of information about lifting capacity was reported by Snook.[30] He tabled the maximum safe weight for both males and females by percentile (i.e., 10, 25, 50, 75, and 90), by type of lift (i.e., floor-to-knee, knee-to-shoulder, and shoulder-to-reach), by width of object (i.e., 36, 49, and 75 cm) by the vertical distance the object is lifted (i.e., 25, 51, and 76 cm), and by frequency of lift (i.e., eight intervals ranging from once every 5 seconds to once every 8 hours). These tables were based on six studies conducted by Snook and his associates over a period of years. Some of the combinations of height of lift and weight of object listed in the tables were actually tested in the studies while other combinations were estimated from nearby points.

Recent studies have moved away from measuring simple performance to focus on the relationship between the performance on isometric strength tests such as those ARIEM has proposed and the performance on dynamic strength tasks. In a study by Garg,Mital, and Asfour,[31] both static strength test and dynamic lifting ability were measured for each person in the study to determine how well they correlated. The results from their dynamic task of lifting from 38 to 81 cm (15 to 32 in.) indicated that 92 percent would meet the medium ARIEM strength standards, but only 75 percent would meet the high. By comparison, results from a close-in vertical isometric test indicated 96 percent would meet the medium and 91 percent the high standards, while a vertical static

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[28] Emanuel, et al., op cit.

[29] Switzer, op cit.

[30] Snook, op cit.

[31] A. Garg, A. Mital, & S. S. Asfour. A comparison of isometric strength and dynamic lifting capability. Ergonomics, 1980, 22, 475-486.

lift measure taken near the origin of the dynamic lift indicated 33 percent would meet the medium standard and only two percent the high. To further complicate matters, the object type versus lift value relationships among the various tasks were not always the same. If the object to be lifted was very wide, then the close-in static test underestimated the dynamic task performance rather than overestimated it, as occurred with the compact box. The best predictor of lifting (r = .79) was holding the weight at the origin of the lift for a short period of time (i. e., count to four). The authors note this still leaves over a third of the variance unexplained. Dynamic lifting correlated only r = .48 with a static vertical task, which means that over three-quarters of the variance in the lifting task could not be predicted with the static test. A correlation of r = .74 between static and dynamic tasks was reported by Vogel, Wright, & Patton,[32] but the results have not been published. One would expect even lower correlations when the isometric and dynamic tasks were more dissimilar than those found in these studies.

Better prediction might be obtained using multivariate models which used various static strength measures combined with anthropometric information. This was done by Mital and Ayoub[33] where they found they could predict 85 to 90 percent of the lifting capacity from static strength. They defined lifting capacity as body weight plus weight lifted. Examination of their models showed that the predictors for lifting capacity included composites involving body weight and, thus, some of the correlation obtained must be attributed to the correlation of body weight with itself which means the correlation would go down if only the amount lifted were predicted. The results of these studies clearly indicate that it is difficult to predict dynamic performance from static strength measurements even in carefully controlled conditions.

Part of the difficulty in predicting lifting performance from isometric tests in these experiments may rest in the physical and physiological differences in the two acts.[34] Analysis of the physical system used in lifting is complicated because the lever arrangements, muscle length and momentum of the object are constantly changing during a lifting act. It is further complicated because in a strictly physical sense no work is done in an isometric task, but a measurable amount of energy is expended by the body to maintain any constant force. Physiological processes also work in different ways depending on whether the task is isometric or dynamic. Maintaining an isometric force restricts the flow of blood to the muscles, while a dynamic act facilitates the blood flow. When various aspects of the lifting act are considered separately, different limiting factors are suggested. Conservation of the total energy expenditure would lead to the recommendation that a few heavy loads be carried at low speed, whereas biomechanical criteria would lead to the recommendation of dividing the task into a large number of

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[32]Vogel, Wright, & Patton, op cit.

[33]A. Mital & M. M. Ayoub. Modeling of isometric strength and lifting capacity. Human Factors, 1980, 22, 285-290.

[34]K. H. E. Kroemer. Human strength: Terminology, measurement, and interpretation of data. Human Factors, 1970, 12, 297-313.

light loads to reduce the chances of back injuries.[35] A classic example of the conflicting predictions involves the straight-back, bent-knee method, which is the safe lifting procedure prescribed by most safety experts.[36] This method requires a much greater energy expenditure than the stooped-back method because the weight of the body must be lifted each time. The straight-back, bent-knee method may be satisfactory for occasional lifts, but is not likely to be used by individuals who have to move a great many objects.

In their review of strength testing, Garg and Ayoub came to the conclusion that it was difficult to specify general maximum weight criteria based on the current state of the art. They also found most screening procedures based on medical information were inadequate and that there was no evidence that safe lifting programs produced any reduction in accidents. They did conclude that a combination of preemployment screening and job design would reduce injuries. They felt that jobs requiring frequent lifting should use metabolic energy expenditure criteria, while those requiring infrequent lifting should base their criteria on biomechanical limitations. While they did not say it specifically, there is a strong implication that strength testing should be tailored to the job.

It is clear that the number of MOS having strength standards must be reduced to a minimum. The foremost reason is to bring the number of jobs requiring strength down to a manageable size so selection can be effective. A second reason is to reduce the range of tasks requiring strength screening so that the strength tests are more appropriate to the job. A third reason is to reduce the hazard of on-the-job injury by reducing the strength required to do many Army tasks. Keeping these three goals in mind, an interview was conducted with soldiers working in five different MOS to determine what changes might be made in their jobs to reduce the strength requirements.

Method

Selection of MOS for the Survey

Soldiers from five different MOS were surveyed for the physical demands job analysis. These were selected from MOS that had both mental aptitude and physical demand requirements as evidenced by a mean male AFQT percentile of 55 or greater and assignment to an ARIEM cluster with above the baseline. Ninety-five MOS with 105,627 soldiers Army-wide met these two requirements. This list was shortened by removing combat arms specialties and those MOS which had manning levels at Fort Hood that would not provide enough people for interviews (F50 assigned). From this list of 16 MOS, a representative sample of five were selected that included a range of the kinds of specialties that work with combat units and a range of physically difficult tasks.

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35 A. Garg & M. M. Ayoub. What criteria exist for determining how much load can be lifted safely? Human Factors, 1980, 22, 475-486.

36 Navy Lifeline, op cit.

Each of the five MOS selected came from a different branch of the Army. The Radio Operator (05B) is a signal specialty which is representative of jobs in which a soldier is required to operate sophisticated electronic equipment in a field environment. The Power Generation Equipment Repairer (52D) is an engineering specialty which is representative of the many mechanical equipment repair jobs in which the soldier must have both the ability to identify and repair malfunctions and the ability to handle heavy pieces of equipment. The third MOS selected was to be a specific type helicopter repairer from the transportation specialties, but instead repairers for four types of helicopters were questioned because the company providing support for the research had only a few soldiers in each MOS. These soldiers will be referred to simply as Helicopter Repairers (67-). The MOS represented are: Utility Helicopter Repairer (67N), Medium Helicopter Repairer (67U), Observation/Scout Helicopter Repairer (67V), and Attack Helicopter Repairer (67Y). The helicopter repairer is a specialty which is representative of jobs where the soldiers usually have to go to the equipment to work on it rather than bringing it in to the shop. The Medical Specialist (91B) is part of the medical corps which, along with other specialists in this field, moves with troops to provide emergency aid and evacuation services. The Electronic Warfare/Signal Intelligence Voice Interceptor (98G) is part of military intelligence. Like the radio operator, soldiers holding MOS 98G must operate and handle electronic equipment while in the field, and in addition, they must carry out the difficult task of intercepting and translating enemy communications in a timely manner.

Participants

Personnel of both sexes in pay grades E3 through E7 were requested for each MOS. However, the units providing the personnel did not have the requested mix so substitutions had to be made. Table 2 shows the actual number of each sex for each MOS for each pay grade category that were available for interviewing. The numbers requested are shown at the top of the table. All participants were working in their primary MOS.

TABLE 2

MOS, Pay Grade, and Sex of Soldiers Interviewed

	E2 - E4		E5 - E6		E7		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
MOS								
(Requested)	(4)	(2)	(2)	(1)	(1)	(0)	(7)	(3)
05B	5	2	1	0	2	0	8	2
52D	4	0	5	1	0	0	9	1
67-	3	3	1	0	3	0	7	3
91B	4	2	3	0	1	0	8	2
98G	3	2	3	2	0	0	6	4
Total Obtained	19	9	13	3	6	0	38	12

Procedure

The structured interview was preceded by a briefing about the project. In it the researcher introduced himself and gave the soldier a short background on the Army's interest in screening for physical abilities. The need to select individuals for certain jobs was emphasized, as were the problems that might be produced if too many MOS were included in the selection procedure. To encourage participation, it was pointed out that MOS that required high aptitude and high strength, "like the soldiers being interviewed," presented special selection problems. Any questions they raised were answered.

The structured interview consisted of three parts. The first part obtained information for a short list of personal data items which might relate to physical ability. This was followed by a series of questions on the physical nature of the tasks required by the MOS and the general amount of physical difficulty experienced. The third part of the interview consisted of detailed information about tasks identified as physically difficult. The full texts of the interview questions are given in Appendix B.

In addition to obtaining the personal data in the first part, the soldiers were asked what they considered the most physically demanding tasks for their MOS. After recording the initial response, they were prompted with phrases such as "what makes you tired?," "what is the heaviest thing you have to pick up?," and "what has strained you?" In answering, the soldier was asked to be as specific as possible about the task. Some responses such as "doing the PT test" were not recorded because they were not specific to the soldier's MOS.

The next part of the interview consisted of a series of items about specific physical abilities. The soldier was asked to state which tasks required each ability and how much time was spent using the ability to do the task. For example, a reply to the item "body strength" might be "move supplies one hour per week." This was followed by a series of general questions about the physical requirement of the job as a whole.

The last part of the survey elicited additional information on the tasks identified previously as physically difficult. The soldier was read the tasks he or she had identified as physically demanding and asked if any additions or other changes should be made in the list. If there were, the list of tasks was modified. In two cases--a helicopter repairer and a medical specialist--no physically difficult tasks were identified, so this part of the interview was skipped. For the others who did list difficult tasks, the information collected for each task included frequency, duration, height lifted, and distance moved. This was followed by a series of questions on the difficulty of each task. Because the interview was semi-structured some soldiers answered these last questions for each task separately, while others considered all the tasks they had given as a group. Additional comments on the tasks were elicited and recorded if relevant to physical demands.

After the interview the soldier was asked if it was possible to see the pieces of equipment involved in the difficult tasks. In some cases it was possible to identify the specific characteristics of the equipment that made it physically difficult to use. It was clear, for instance, that the square handrails on the small generator sets made them difficult to carry. The soldiers were then debriefed and asked if they had any other questions regarding the project. These were answered and the soldier thanked for his or her participation.

Results

Two basic types of information were collected from the soldiers in this study. The first consisted of the personal data which was used to determine whether factors not directly related to the job (e.g., an individual's size) could affect the physical difficulty of tasks. The second type of information came from the job analysis interview. The semi-structured nature of the interview led to a broad range of responses for many items. Only those results that have important implications for physical demands are discussed. Further tabulation of the results is presented in supplementary tables in Appendix A.

Personal Data

It was expected that a soldier's physical strength would affect how he or she perceived the difficulty of the job. The hypotheses were that females would find tasks more difficult than males since the latter are typically stronger, that older soldiers would find tasks more difficult than younger since the younger soldiers are likely to be in better condition, and that smaller soldiers--either shorter or lighter--would find the task more difficult than larger ones since the larger soldiers would likely be stronger.

These hypotheses were tested by correlating the number of difficult tasks with the continuous personal data variables and by an analysis of variance for sex. The test results are shown in Table 3. None of the product moment correlations of interest was significant ($p > .05$). Since the difficulty measure only took on four discrete values in this sample (i.e., 0, 1, 2, or 3 difficult tasks), a nonparametric measure of association, the Spearman rank order correlation coefficient was also computed. None of the correlations of interest were significant by this test either. A one-way analysis of variance was used to compare the number of difficult jobs for males and females and it was found to be nonsignificant ($F(1, 48) = 2.46$; $p > .05$).

Since there was a considerable difference in the size and experience of the males and females surveyed, the data for the 38 males were analyzed separately. For the males only, there was a significant correlation between the number of difficult jobs and the age of the soldiers ($r = .29$; $p < .05$). No other significant correlations with number of difficult tasks were found, nor were any found when only low ranking (i.e., E4 and below) soldiers or high ranking were considered separately.

The males and females differed on all of the measures obtained as shown in Table 4. The males had more time in service ($F(1, 48) = 6.51$; $p < .05$), were older ($F(1, 48) = 5.06$; $p < .05$) were taller ($F(1, 48) = 7.99$; $p < .01$), and were heavier ($F(1, 48) = 23.32$; $p < .01$) than the females. The five MOS did not differ on any of the four personal data measures or on the number of difficult tasks reported ($p > .05$). A summary of the difficult task data is shown in Table 5. When the pay grade was considered, there was a significant difference in time in service ($F(5, 44) = 107.68$; $p < .01$, age ($F(5, 44) = 22.24$; $p < .01$) and weight ($F(5, 44) = 3.64$; $p < .01$) as expected but not in height ($F(5, 44) = .43$; $p > .05$) or number of tasks ($F(5, 44) = .63$; $p > .05$).

TABLE 3

Intercorrelation of Personal Data Variables and Number of Physically Difficult Tasks for All Soldiers in Study
(values in parentheses are Spearman rank order correlations)

N = 50

	Time in Service	Age	Height	Weight
Age	.8914** (.8971**)			
Height	.1468 (.1108)	.1932 (.1673)		
Weight	.4677** (.3498*)	.4583** (.3726**)	.6356** (.6496**)	
Difficult tasks	.1428 (.1051)	.1696 (.1274)	-.1592 (-.1240)	-.0945 (-.1101)

*$p < .05$
**$p < .01$

TABLE 4

Summary Characteristics for Males and Females in the Overall Sample

	Mean[b]	Standard Deviation	Percentile 25th	Percentile 50th	Percentile 75th	Range Min	Range Max
Males N = 38							
Time (months) in service	85.45*	75.34	27.0	48.5	144.0	8	236
Age (years)	27.66**	8.42	21.0	24.5	32.0	19	51
Height (cm)	176.34**	8.51	170.0	175.0	183.0	155	193
Weight (kg[a])	78.39**	10.67	72.7	79.8	86.4	54.5	101.8
Females N = 12							
Time in service	28.67	24.47	13.0	15.5	39.0	7	90
Age	22.00	3.64	19.0	21.5	24.0	19	31
Height	168.42	8.32	161.5	169.0	173.5	157	185
Weight	62.31	7.64	56.8	61.4	67.0	51.4	76.4

[a]Converted from pounds to kilograms and rounded to the nearest 0.1 kilogram. All other measures were converted if necessary and rounded to the nearest unit.

[b]Significant mean differences between males and females are indicated by:
*$p < .05$
**$p < .10$

TABLE 5

Number of Difficult Tasks Reported as Function of Sex, Rank, or MOS

	Nr.	Mean	Standard Deviation	Percentile 25th	Percentile 50th	Percentile 75th	Range Min	Range Max
				Sex				
Males	38	2.00	.805	2.0	2.0	3.0	0	3
Females	12	2.42	.793	2.0	3.0	3.0	1	3
				Rank				
E2	7	1.71	.756	1.0	2.0	2.0	1	3
E3	10	1.90	1.287	1.0	2.5	3.0	0	3
E4	11	2.27	.647	2.0	2.0	3.0	1	3
E5	8	2.25	.463	2.0	2.0	2.5	2	3
E6	8	2.25	.707	2.0	2.0	3.0	1	3
E7	6	2.17	.753	2.0	2.0	3.0	1	3
				MOS				
05B	10	2.40	.699	2.0	2.5	3.0	1	3
52D	10	2.30	.675	2.0	2.0	3.0	1	3
67-	10	1.70	.949	1.0	2.0	2.0	0	3
91B	10	1.90	.994	1.0	2.0	3.0	0	3
98B	10	2.20	.632	2.0	2.0	3.0	1	3
				OVERALL				
	50	2.10	.814	2.0	2.0	3.0	0	3

Difficult Tasks Questions

The soldiers responded to the question on the physically difficult tasks in their job by naming 105 examples--a mean of 2.1 tasks per individual. These 105 were classified into 43 separate tasks on the basis of the descriptions given to the interviewer. This list of tasks gives a good picture of what kinds of effort made the jobs of these soldiers physically difficult. To facilitate discussion, the tasks have been grouped into two major categories based on the generality of the task (e.g., is it something that would be common to several MOS or specific to only one) and into minor categories based on the similarity with other tasks (e.g., materials handling, vehicle maintenance). Some of the tasks were quite easy to classify as general or specific. Moving supplies is something that almost any soldier is likely to do, and thus is in the major category of "General Tasks" and in the minor category "Handle Material." Replacing the main rotor on a helicopter, on the other hand, is something that only a helicopter repairer is allowed to do, and thus is in the major category "MOS-specific tasks" in the minor category "Work on Helicopter." Between these extremes were a number of tasks that could not be classified clearly as general or specific. The limited sample of MOS prevented an empirical clustering, so the author and two colleagues used judgment to assign the tasks to minor categories and then to classify these categories as either general or specific. An example of an uncertain minor category is "Use Portable Generator," which consists of tasks primarily reported by radio operators. This would seem to make it an MOS-specific category if it were not for the fact that these portable generators are used by many MOS that take electronic equipment into the field. For this reason, it was classified in the general tasks category, although all but one instance of the task was reported within that single MOS.

The specific steps for the clustering procedure were:

(1) descriptions of all the physically difficult were listed;

(2) tasks were combined under one name when the interview records indicated they were physically similar;

(3) the tasks within each MOS were grouped into categories; and

(4) the categories were compared across the five MOS and revised as necessary to be consistent.

The clustering procedure described above led to seven minor task categories. Four categories representing 63 reports (60%) were considered to be general tasks, while three categories representing 42 reports (40%) were considered to be MOS-specific. A listing of the categories and the tasks making them up is shown in Table 6.

The general categories were:

(1) Handle Material: These tasks all involved moving or lifting heavy items. No special skills were required and the purpose was usually to get the items into place for use or return them to storage.

(2) Establish Field Site: These tasks all involved the exercise of common soldiering skills, such as pitching a tent, which are necessary to set up an operation in the field.

TABLE 6

Categories for Physically Difficult Tasks by MOS

General Tasks

	Total	MOS 05B	52D	67-	91B	98G
Handle Materials						
Move Equipment & Supplies	9	3	2		1	3
Move Power Cables	4					4
Carry Toolbox	4			4		
Install Equipment	4	3				1
Move Radios	3	2				1
Load Trucks	3		2			1
Move Power Supplies	2	2				
Carry Backpack	2	1			1	
Move Fuel Cans	1		1			
Carry Aid Chest	1				1	
Move Camouflage Bags	1					1
Category subtotals	35	12	5	4	3	11
Establish Field Site						
Put up Tent	6	3			3	
Set up Antenna	3	3				
Set up Camouflage Nets	3					3
Set up Aid Station	2				2	
Drive Ground Rod	1	1				
Put up Maintenance Tent	1		1			
Dig in	1					1
Category subtotals	17	7	1		5	4
Use Portable Generator						
Pick up Generator	2	2				
Start Generator	2	1	1			
Set up Generator	1	1				
Maintain Generator	1	1				
Category subtotals	6	5	1			
Work on Vehicle						
Change Tire	3				1	2
Maintain Vehicle	2				1	1
Category subtotals	5				2	3
TOTAL General Tasks	63	24	7	4	10	18

MOS-Specific Tasks

	Total	MOS 05B	52D	67-	91B	98G
Work on Generator						
Connect Trailer to Truck	7		3			4
Move Small Engine	4		4			
Lift Small Engine	4		4			
Operate Trailer Jack	2		2			
Loosen/Tighten Bolts	1		1			
Change Small Engine	1		1			
Remove Large Components	1		1			
Category subtotals	20		16			4
Work on Helicopter						
Ground Handle Aircraft	3			2		
Torque Rotor Nut	2			2		
Replace Engine & Transmission	2			2		
Replace Main Rotor	1			1		
Replace Tail Rotor	1			1		
Replace Wing	1			1		
Replace Starter/Generator	1			1		
Work in Small Space	1			1		
Handle Large Components	1			1		
Category subtotals	13			13		
Carry Casualty						
Bear Litter	8				8	
Manually Carry Casualty	1				1	
Category subtotals	9				9	
TOTAL MOS-specific	42	0	16	13	9	4
TOTAL All Tasks	105	24	23	17	19	22

MOS 05B -- Radio Operator
MOS 52D -- Power Generation Equipment Repairer
MOS 67- -- Helicopter Repairer
MOS 91B -- Medical Specialist
MOS 98G -- Electronic Warfare/Signal Intelligence Voice Interpreter

(3) Use Portable Generator: These tasks were required to use the portable electric generators required to power field sites.

(4) Work on Vehicle: These were operator maintenance tasks required for the vehicles assigned to a unit.

The MOS-specific cateories were:

(1) Work on Generator: These were tasks required to repair the portable generators in the repair shop.

(2) Work on Helicopter: These were tasks required to repair helicopters brought in for maintenance.

(3) Carry Casualty: These tasks were required to evacuate casualties to transportation or to aid station for further medical attention.

When the proportion of the two radio operator types of difficult tasks within an MOS were considered, two types of jobs were identifiable. In the first type, most of the tasks were in the general category. This included radio operator with 100 percent general tasks and intelligence specialist with 81.8 percent common. In the other kinds of MOS, most of the tasks were in the MOS-specific category. This included the generator repairer with 30.4 percent general tasks and helicopter repairer with 23.5 percent. The medical specialists were not clearly of either type since they had almost an even split with 52.6 percent general tasks.

Considering these MOS as coming from two distinct groups with the medical specialist (possibly) representing a special case provides a way to organize the methods used by soldiers in each MOS to cope with physically difficult tasks. The two MOS with a majority of general tasks were those that supported combat arms troops in the field, the radio operators and intelligence specialists. The second group of MOS which had a majority of physically difficult tasks that were unique to the specialty were the two groups of maintenance personnel, helicopter and generator. Even the general tasks the repairers did mainly involved the movement of the heavy parts of the equipment being repaired. The medical specialists reported a high incidence of a task that occurred in the field, carry casualties, but it is specific to the medical series of MOS (91-). Only descriptive statistics for this categorization are reported since any inferences would be biased by having formed the groups based on the results.

The question arises as to whether the two categories of tasks are different in the severity of the physical demands they make. Three of the interview questions addressed this issue. The questions were: "Are you tired after doing this task?"; "Have you ever strained yourself?"; and "Do you know of anyone having trouble with this task?" Tasks with affirmative answers to any of these questions are presumably more difficult than those without them. On 20 tasks (19.0%) the soldiers reported that they had strained themselves. A positive response was given to the question about being tired for 79 (75.2%) tasks and the soldiers reported knowing of others having difficulty for 49 (46.7%). Table 7 shows the number and percent reporting an affirmative answer to each of these questions as a function of the task category. For the questions about being strained and being tired, the tasks in the specific to an MOS category showed a higher percentage of affirmative responses, while the reverse was true of the question of knowing persons

TABLE 7

Number and Percentage of Tasks Receiving Affirmative Responses to Questions About Task Difficulty

	Strained Themselves	Felt Tired	Others Have Trouble
Handle Material	8 (22.9)	25 (71.4)	19 (54.3)
Establish Field Site	0 (0)	12 (70.6)	7 (41.2)
Use Portable Generator	3 (50.0)	5 (83.3)	3 (50.0)
Work on Vehicle	0 (0)	3 (60.0)	2 (40.0)
General Tasks	11 (17.5)	45 (71.4)	31 (49.2)
Work on Generator	4 (20.0)	18 (90.0)	7 (35.0)
Work on Helicopter	2 (15.4)	10 (76.9)	5 (38.5)
Carry Casualty	3 (33.3)	6 (66.7)	6 (42.9)
MOS-specific Tasks	9 (21.4)	34 (81.0)	18 (42.9)
All Tasks	20 (19.0)	79 (75.2)	49 (46.7)

having trouble. Thus, the relative difficulty of the two major categories of tasks may be about the same.

Difficulties For Specific MOS

There are characteristic physically difficult tasks for each MOS that need special mention. These are ones that contribute the most to making a particular MOS physically demanding, and hence, are the ones that must be dealt with in any job modification program. These are listed below by MOS.

The heaviest tasks for Radio Operators (05B) involved moving equipment to and from the storage area so it could be transported to the field. A great deal of physical effort was required to carry heavy receivers and power supplies up and down stairs. The soldiers in this MOS also reported difficulty in handling the portable generators for which their mean estimate of weight was 120 kg (263 lb.). These are usually mounted on a trailer but must be moved for storage and for operator maintenance.

Most of the difficult work for Power Generation Equipment Repairers (52D) involved moving equipment or parts of equipment around so it could be serviced. Job aids such as wheelbarrows and carts were used to carry the engines and "A" frames were used for hoisting where possible. The soldiers who worked with the large generators reported that hooking up the trailers to trucks was a very difficult task which required several persons to accomplish.

Carrying the toolbox was the most common difficult task for Helicopter Repairers (67N, V, and Y). The mean estimate of the tool box weight was 25 kg (56 lb.) and it frequently had to be carried some distance to the flight line. Other difficult tasks involved handling heavy or bulky parts of the helicopter being serviced. Because maintenance personnel for several different types of helicopters were surveyed, no specific handling task was reported more than a few times.

The Medical Specialists (91B) had one physically difficult task that overshadowed all the others--carrying casualties. Two persons may be required to carry a casualty and litter combination that they estimated a mean weight of 87 kg (192 lb.) for distances of 100 meters or more for treatment or evacuation. This would have to be done over and over again during combat which requires that medical specialists have both high stamina and high strength. This task reportedly required four female soldiers.

Most of the physically difficult tasks for Electronic Warfare/Signal Intelligence Voice Interceptors (98B) were related to setting up or taking down a field site. Moving the heavy power cables necessary to connect the electronic equipment to the generators was a common task. There was a great deal of heavy equipment that had to be moved whenever a field site was set up. Because this specialty may work close to the battle area, it is essential that the time required to move and set up be kept to a minimum.

Conclusions and Recommendations

The ARIEM study had correctly identified the five MOS in this job survey as having physically demanding tasks. All but two of the 50 persons interviewed reported at least one demanding task as part of their job, and some reported as many as three. These tasks were classified either as being general to many MOS or as being specific to only one type. General tasks were the kind of thing every soldier is required to do such as carrying supplies, setting up tents, or working on a vehicle. The specific tasks were related directly to the work done in the MOS such as tightening the rotor nut by a helicopter mechanic or carrying a casualty by a medical specialist. Four of the five MOS could be classified on the basis of having either a majority or minority of the general tasks. Field technical specialists jobs had a majority of general physically difficult tasks. Repair shop specialists, by contrast, had jobs where most of the physically difficult tasks were MOS specific. The fifth MOS, the medical specialist, had almost an equal proportion of the two types of tasks.

The success the soldiers had in dealing with the difficult jobs in part depended upon which type of job they had. Those soldiers working in shops generally found ways to reduce the physically demanding aspects of their jobs. Hoists or other tools were used to lift heavy parts, while carts were used to move heavy equipment. These tasks were done on a frequent basis as part of the day-to-day routine and the individuals had developed methods to cope with them. For example, the heavy tool box used by the helicopter repairers was reported as a physically difficult item to carry and soldiers felt they could benefit from some sort of cart to move it. In fact, one organization had a sheet metal shop construct some carts just for carrying the tool boxes. For those who did not have the cart, a common approach was to put the tool box down occasionally to get a rest. It might take the person a few minutes extra to get out to the helicopter on the flight line using this method to move the tool box, but because mechanics worked on the helicopters for several hours at a time, the few minutes extra were not considered to be significant. Another instance of coping with difficult tasks occurred in the generator repair shop. There was a female soldier who found that her small size made it difficult to loosen stuck bolts in the way male soldiers did. She compensated by making her hammer and "cheater" bar two of her most used tools. Despite her size, she was able to carry out the full job and her supervisor considered her as one of his best helicopter repairers. The physical difficulties of the tasks in the shop were overcome because it was essential if the work was to be accomplished. Quite simply, if the parts are not moved to the workbench, then they cannot be repaired. Since other units need the repaired equipment, there was pressure to get the job done and, thus, ways were found to do the physically difficult tasks.

The physically difficult tasks for the field technical specialist occur in a different situation. Instead of being part of the day-to-day routine, these difficult tasks are primarily combat support activities that currently are carried out only during field exercises. The most common category of physically difficult tasks for these MOS are material handling activities. These are typically associated with on-the-job injuries in industry.[37] The soldiers must carry their equipment and supplies from storerooms to vehicles. They then transport it to the field where the soldiers carry it again to the tents where it is to be used. When the exercise is finished, the equipment must be returned to the storerooms. This process may be repeated several times during an exercise if the unit changes location. The second category of difficult tasks, set up a field site, is also associated with field exercises. The tents are heavy and it requires a strong person to hold the main pole while the stakes are being driven. In addition to being heavy, the

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[37]D. B. Chaffin. Human strength capability and low-back pain. Journal of Occupational Medicine, 1974, 16, 248-254.

camouflage nets must be handled while working in awkward positions such as on the top of a truck or shelter. Support tasks such as these are perceived by some soldiers as diverting them from their primary duties and thus they may not be willing to put much effort into accomplishing them.

There was a sharp contrast between the two field technical specialty MOS in how they dealt with these physically difficult tasks. Those soldiers in military intelligence cooperated with each other to carry out the tasks. They viewed the movement and setting up of equipment as a necessary, if undesirable, part of getting their primary job done. Nearly all of them recognized that it was essential to be able to move a field site quickly if they were not to become easy targets for the enemy. By working together to carry heavy equipment and to set up tents and camouflage nets, no one had to carry a load that was too heavy. The heaviest tasks, such as holding the ridge pole while setting up the tent, were assigned to the strongest person in the group. The radio operators, in contrast, reported less cooperation on physically difficult tasks. One female soldier reported that she had to drag a heavy generator into position for testing by herself while other members of the work team who were free only watched. Some soldiers in this MOS reported that others were "shirking their duties" and that the interviewee felt he or she was doing more than his or her share of the heavy work. The radio operators reported carrying power supplies and radio sets weighing in excess of 50 kg (110 lb.) by themselves. This may account for the radio operators having the largest proportion of persons (50%) reporting work-related strains. An indirect confirmation of this observation came from a medical specialist in the survey who volunteered that many of the strains he had treated involved radio operators who tried to lift heavy equipment.

Unlike the shop mechanic whose day-to-day work is much like his or her industrial counterpart, the day-to-day work of the field technical specialist consists of administrative duties with very little physical work. The unit leader has little information from ongoing work to indicate whether the soldiers can accomplish the physically difficult parts of the job. Success in coping with these tasks probably depends on both the quality of training and the leadership provided. Differences in these two factors may have been what accounted for the difference observed between the job handling of the intelligence specialists (who worked together) and the radio operators (who did not cooperate).

One task did not fit into either of the two patterns just discussed. This was the litter bearing requirement of the medical specialist. This task can be both extremely strenuous and very exhausting. Soldiers with experience in Vietnam reported having carried casualties up to 16 hours a day. Most of the medical specialists reported that while two men can carry a litter, it typically takes four women. Assuming this is true, this means that if women are assigned the task, medics are taken away from their even more important job of treating the injured. Thus, a labor-intensive solution is ruled out because of the frequency with which the carries must be made under emergency conditions. Job aids would not help either because of the ruggedness found in the field environment.

The results of this survey suggest that the physical demands of some tasks could be reduced without major changes to an MOS. The most straightforward change would be to assign more persons to the job. Many of the materials handling tasks are difficult because of the awkwardness of the object being moved. Gloves should be available to reduce the pressure on the hands from sharp edges on things such as battery straps or generator frames. The generator frame could also benefit from a redesign to provide a better grip.

Safety programs such as those carried out by the Army's aviation center need to be provided for other MOS to warn soldiers of potentially dangerous physical tasks. Top priority needs to be given to keeping all job aids, such as hoists and "A" frames, available and working. Soldiers should know that forklifts are available and that they should not risk injury by lifting a heavy object onto a high truckbed.

Physical fitness is essential for every soldier who might go into combat. It is clear that the peacetime level of effort in jobs such as medical specialist is not going to keep a soldier fit enough to operate under wartime conditions. The Army has taken a good step in this direction by increasing its physical fitness requirements.[38] Such additional physical training must be given to all soldiers, regardless of how well they perform on any screening tests.

Summary

As ARIEM has stated, there are many tasks in the Army that require more strength or stamina than can be expected from each and every soldier. Assigning people who do not have the required fitness to do these tasks is going to lead either to the task not being done or the soldiers being injured. Either way, the Army's long-range goals are ill served. A review of the research on the strength of the working population showed that while there is some disagreement among the experts on just how much can be safely lifted, it is likely that between 25 and 68 percent of the soldiers might be able to do the heaviest Army tasks of lifting 39 kg (86 lb.) or more to a truckbed height (137 cm ,4.5 ft..).

Recommendations

The pool of physically fit soldiers represents a fixed asset for the Army. Selection can be used to assign them to the most critical jobs, but it cannot increase their number. Most of the physically fittest soldiers must be assigned to the combat arms specialties where there is no substitute for strength. Few job aids are available to the tank crew which must change a track in the heat of battle. In the same way, the number of high aptitude individuals is also limited. Most of these individuals must be assigned to the MOS that require high aptitude to successfully complete their training and carry out their jobs. The inner workings of computers or the human body require a degree of aptitude to understand that is not possessed by all soldiers. The alternative to selection that was most commonly suggested by the interviewees was to use more personnel to accomplish a task. Many physically difficult tasks are done by persons working in groups so that either more than one person can help with a task or the stronger individuals in the group can be assigned to do it. Using more soldiers is applicable where the physically difficult tasks are done infrequently and the addition of the extra workers to accomplish them would not compromise the mission. This would not be possible for an MOS where the physically difficult task takes up much of the time. An example of sharing the work occurs when setting up a field site which requires carrying some heavy equipment and putting up tents and camouflage nets. A coordinated group effort would allow this to be done in a reasonable amount of time without putting undue strain on anyone. When the work cannot be shared effectively because of time constraints or other limitations, the most effective

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[38] Tougher, standardized PT testing adopted by Army, op. cit.

procedure may be to assign the task to another, less critical MOS. This should be one that already has other physically demanding tasks. An example is carrying of casualties in wartime conditions, which can occupy most of the available time of the medical specialist. This task might be assigned to another MOS which has other physical demands but not as high an aptitude requirement, thus releasing medical personnel for the critical job of providing aid to the casualties. This should also reduce the number of medical specialists required, as each could spend more of his/her time in providing direct aid to casualties.

Changes can be made in some tasks that will reduce the maximum amount of physical strength required for an MOS without affecting the mission of the specialty. This is a common approach used by industry but very few task modifications were suggested in the survey.

The selection problems are the most difficult for those MOS that require both high aptitude and physical fitness. Unless circumstances change, there will not be enough soldiers who possess both qualities to fill the required positions. This can be solved by changing the tasks to require less strength or transferring the physically demanding tasks to other MOS with lower aptitude requirements. By doing this a three-fold benefit will accrue: (1) the number of high aptitude MOS requiring high standards of physical fitness will be reduced, (2) the total number of soldiers required for high aptitude jobs will also be reduced (because part of their workload will have been shifted elsewhere, as in the case of the medical specialist), and (3) since the most physically demanding tasks will be eliminated from high aptitude MOS, more soldiers will be physically qualified and available for assignment to those MOS having either high aptitude only requirements or both high aptitude and high physical fitness requirements.

This approach can be illustrated by considering the medical specialist MOS (91B). As the job is now structured, casualty evacuation tasks such as litter bearing place this job in the highest physical demand cluster for both strength and stamina. Patient care requirements mean that the MOS also requires above average or high mental aptitude for success. It is estimated that less than half of the soldiers now entering this MOS meet both these requirements. By reassigning the physical aspects of the casualty evacuation task and other heavy tasks to another MOS (possibly a new one) which already has high fitness requirements (but relatively low aptitude requirements), the number of persons who could be assigned to medical specialties is substantially increased. This would also have the added benefit of reducing the number of medical specialists required to staff the medical support units. By a reshuffling of physically demanding and other non-technical duties to one group of soldiers, and all medical duties to another group, the percentage of high aptitude medical personnel required in the medical company can be reduced and still provide the same quality and quantity of medical care as before. (These non-medical personnel could be given a short first aid course, if desired.)

Modifying jobs to reduce physical demands would have other benefits in addition to increasing the number of people available for assignment. A direct benefit would be a reduction of on-the-job injuries currently resulting from excessive lifting. This would represent significant savings to the Army in terms of both manpower, by increasing the number of days soldiers are at work, and dollars by reducing medical and disability costs. Carrying out this approach would mean that only those MOS that really require high physical fitness standards would have such standards. This is exactly what the equal opportunity law requires, so the Army would not be in its currently vulnerable position of being charged with sexual discrimination. Finally, the elimination of what soldiers feel are unnecessary physical tasks unrelated to their education and technical competence will serve to increase morale with accompanying higher reenlistments.

In conclusion, at a time when the Army is facing a decreasing manpower pool, the proposed concept of job design and task reassignment advocated here will effectively increase the manpower available for critical MOS while simultaneously reducing the number of personnel requiring both high aptitude and a high degree of physical fitness.

References

A new way to lift. Navy Lifeline, September 1973, 16-17.

Ayoub, M. M., Mital, A., Asfour, S. S., & Bethea, N. J. Review evaluation, and comparison of models for predicting lifting capacity. Human Factors, 1980, 22, 257-269.

Ayoub, M. M., Powers, R. F., Bethea, N. J., Lambert, B. K., Martz, H. F., & Bakken, G. M. Establishing criteria for assigning personnel to Air Force jobs requiring heavy work (AMRL-TR-77-94). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, July 1978. (AD A060 114)

Chaffin, D. B. Human strength capability and low-back pain. Journal of Occupational Medicine, 1974, 16, 248-254.

Cook, S. J., & Wilkey, D. R. Social problems of enlisted women in United States Air Force craft skills (AFIT-LSSR-6-77A). Masters Thesis. Wright-Patterson Air Force Base, OH: US Air Force Air University, Air Force Institute of Technology, June 1977. (AD A044 193)

Daniels, W. L., Vogel, J. A., & Kowal, D. M. Guidelines for aerobic fitness training in the US Army (USARIEM T-5/79). Natick, MS: US Army Research Institute for Environmental Medicine, August 1979. (AD A081 431)

Emanuel, I., Chaffee, J. W., & Wing, J. A study of human weight lifting capabilities for loading ammunition into the F-86H aircraft (WADC-TR-56-367). Wright-Patterson Air Force Base, OH: Wright Air Development Center, August 1956. (AD 097 206)

Garg, A., & Ayoub, M. M. What criteria exist for determining how much load can be lifted safely? Human Factors, 1980, 22, 475-486.

Garg, A., Mital, A., & Asfour, S. S. A comparison of isometric strength and dynamic lifting capability. Ergonomics, 1980, 23(1), 13-27.

Knapik, J. J., Wright, J. E., Kowal, D. M., & Vogel, J. A. The influence of US Army basic initial entry training on the muscular strength of men and women (USARIEM M 11/80). Natick, MS: US Army Research Institute of Environmental Medicine, March 1980. (AD A084 084)

Koym, K. G. Development of physical demand profiles for four airman career ladders (AFHRL-TR-75-67). Brooks Air Force Base, TX: Air Force Human Resources Laboratory, November 1975. (AD A020 118)

Kroemer, K. H. E. Human strength: Terminology, measurement, and interpretation of data. Human Factors, 1970, 12, 297-313.

Marston, P. T., Kubala, A. L., & Kraemer, A. J. The impact of adopting physical fitness standards on Army personnel assignment: A preliminary study (Final Report FR-MTRD-TX-80-6). Alexandria, VA: Human Resources Research Organization, March 1980 (rev. February 1981).

Mital, A., & Ayoub, M. M. Modeling of isometric strength and lifting capacity. Human Factors, 1980, 22, 285-290.

Snook, S. H. The design of manual handling tasks. Ergonomics, 1978, 21, 963-985.

Soule, R. G., Pandolf, K. B., & Goldman, R. F. Energy expenditure of heavy load carriage. Ergonomics, 1978, 21, 373-381.

Switzer, S. A. Weight-lifting capabilities of a selected sample of human males (MRL-TDR-62-57). Wright-Patterson Air Force Base, OH: Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, June 1962. (AD 284 054)

Tougher, standardized PT testing adopted by Army. Army, January 1981, 56.

Van Cott, H. P., & Kinkade, R. G. (eds.). Human engineering guide to equipment design (rev. ed.). Washington, DC: US Government Printing Office, 1972.

Vogel, J. A., Wright, J. E., & Patton, J. F., III. Development of new gender-free physical fitness standards for the Army. Proceedings of the 1980 Army Science Conference, West Point, NY. June 1980. (AD A090 445)

Vogel, J. A., Wright, J. E., Patton, J. F., III, Dawson, J., & Eschenback, M. P. A system for establishing occupationally-related gender-free physical fitness standards (USARIEM T-5/80). Natick, MS: US Army Research Institute of Environmental Medicine, April 1980. (AD A094 518)

APPENDIX A

Supplementary Tables

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TABLE A-1

Intercorrelation of Personal Data Variables and Number of Physically Difficult Tasks for Males (values in parentheses are Spearman rank order correlations)

MALES ONLY N = 38

	Time in service	Age	Height	Weight
Age	.8906** (.9077**)			
Height	.0334 (-.0101)	.1016 (.0173)		
Weight	.3734* (.2700)	.4163** (.2888*)	.5195** (.5353**)	
Number of difficult tasks	.2735 (.2588)	.2869* (.2192)	.1104 (-.1336)	.0684 (.0784)

*$p < .05$
**$p < .01$

TABLE A-2

Intercorrelation of Personal Data Variables and Number of Physically Difficult Tasks for Females
(values in parentheses are Spearman rank order correlations)

FEMALES ONLY N = 12

	Time in service	Age	Height	Weight
Age	.6422* (.7477**)			
Height	-.1241 (-.1555)	-.0030 (.0931)		
Weight	.1318 (-.2274)	-.1983 (-.0881)	.7321** (.7982**)	
Number of difficult tasks	.0260 (.0992)	.0944 (.1846)	.0402 (-.0198)	-.0787 (-.1094)

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*p<.05
**p<.01

TABLE A-3

Intercorrelation of Personal Data Variables and Number of Physically Difficult Tasks for Pay Grade E4 and Below (values in parentheses are Spearman rank order correlations)

E4 AND BELOW N = 28

	Time in service	Age	Height	Weight
Age	.5710** (.6744**)			
Height	.1996 (.1509)	.2628 (.1846)		
Weight	.0524 (.0162)	.3322* (.1241)	.6328** (.6406**)	
Number of difficult tasks	.1184 (.0330)	.0726 (.0877)	.1640 (-.1223)	-.2714 (-.3062)

*p<.05
**p<.01

TABLE A-4

Intercorrelation of Personal Data Variables and Number of Physically Difficult Tasks for Pay Grade E5 and Above (values in parentheses are Spearman rank order correlations)

E5 AND ABOVE N = 22

	Time in service	Age	Height	Weight
Age	.7829** (.7993**)			
Height	.4905* (.5197**)	.4857* (.5323**)		
Weight	.7452** (.7346**)	.5820** (.5575**)	.7188** (.6635**)	
Number of difficult tasks	.0633 (.0631)	.1664 (.0989)	-.1060 (-.0959)	.1188 (.1407)

*$p<.05$
**$p<.01$

TABLE A-5

Descriptive Statistics for the Largest Weight Lifted (in kilograms) Reported in the "Physically Demanding Task Description" of the Interview

	Nr. Reported	Mean	Standard Deviation	Percentile 25th	Percentile 50th	Percentile 75th	Extremes Min	Extremes Max
Full Sample	45	40.2kg	21.18	27.0	36.0	45.0	14	113
by Sex								
Males	34	41.7	19.40	30.0	38.0	43.0	18	100
Females	11	35.5	26.80	23.0	23.0	36.0	18	113
by MOS								
05B	10	43.0	27.87	23.0	37.0	54.0	18	113
52D	9	44.4	19.69	34.0	36.0	52.0	27	91
67-	9	31.0	6.89	25.0	30.0	30.0	23	45
91B	9	43.9	19.75	32.0	41.0	45.0	23	81
98G	8	38.2	27.18	19.5	36.0	40.5	14	100
by Pay Grade								
E2	7	30.4	10.26	23.0	27.0	38.5	18	45
E3	8	44.4	29.31	28.5	40.5	43.0	18	113
E4	10	31.7	10.50	23.0	34.0	40.0	14	45
E5	8	49.2	19.55	36.0	40.5	58.0	34	91
E6	6	52.0	34.44	27.0	36.5	91.0	21	100
E7	6	36.5	10.71	29.0	32.0	45.0	27	54

TABLE A-6

Descriptive Statistics for Height of Lift (in centimeters) for the largest Weight Reported in the "Physically Demanding Task Description" of the Interview

	Nr Reported	Mean	Standard Deviation	Percentile 25th	Percentile 50th	Percentile 75th	Extremes Min	Extremes Max
Full Sample	37	114.7cm	39.03	91.0	122.0	137.0	15	183
by Sex								
Males	28	110.3	37.99	91.0	106.5	137.0	15	183
Females	9	128.6	41.23	83.5	137.0	167.5	76	182
by MOS								
05B	9	103.1	33.85	76.0	91.0	137.0	61	152
52D	9	86.1	34.93	68.5	91.0	106.5	15	137
67-	5	140.0	12.55	129.5	137.0	152.0	122	152
91B	7	108.6	34.79	91.0	91.0	106.5	97	183
98G	7	154.6	28.47	129.5	152.0	183.0	122	183
by Pay Grade								
E2	6	116.7	28.39	91.0	122.0	137.0	76	152
E3	5	118.8	48.89	68.5	137.0	160.0	61	183
E4	9	113.2	31.74	91.0	91.0	129.5	91	183
E5	7	93.4	53.91	68.5	91.0	114.0	15	183
E6	5	127.8	39.92	91.0	122.0	167.5	91	183
E7	5	127.8	31.52	99.0	137.0	152.0	76	152

TABLE A-7

Descriptive Statistics for Distance Moved (in meters) for the Largest Weight Reported in the "Physically Demanding Task Description" of the Interview

	Nr Reported	Mean	Standard Deviation	Percentile 25th	Percentile 50th	Percentile 75th	Extremes Min	Extremes Max
Full Sample	33	75.2m	175.21	8.0	27.0	91.0	1	1000
				by Sex				
Males	26	72.9	192.88	8.0	23.5	50.0	1	1000
Females	7	83.7	92.79	16.5	91.0	91.0	6	274
				by MOS				
05B	9	34.2	28.34	7.0	38.0	48.0	3	91
52D	7	36.7	38.54	8.5	27.0	60.5	1	91
67-	6	209.2	390.26	9.0	59.0	122.0	6	1000
91B	5	105.4	106.44	15.5	100.0	198.0	1	274
98G	6	22.3	33.70	8.0	8.5	12.0	6	91
				by Pay Grade				
E2	6	44.2	38.78	9.0	33.0	91.0	8	91
E3	6	63.0	35.92	38.0	68.5	91.0	12	100
E4	8	48.2	91.85	8.0	19.0	28.5	1	274
E5	7	20.9	32.40	4.5	6.0	19.5	1	91
E6	1	122.0	-----	-----	122.0	-----	122	122
E7	5	236.8	429.27	6.0	50.0	561.0	6	1000

TABLE A-8

Tabulation of Positive Responses to the "Jobs Standards Questions" Portion of the Interview by MOS and Sex

Question	Sex	MOS 05B	52D	67-	91B	98G	TOTAL
Are you stong enough to accomplish the tasks in your MOS?	M	8 of 8	9 of 9	7 of 7	8 of 8	4 of 6	36 of 38
	F	1 of 2	1 of 1	1 of 3	1 of 2	4 of 4	9 of 12
Do you have enough stamina to acomplish the tasks in your MOS?	M	8	9	7	8	6	38
	F	2	1	3	2	4	12
Is the physical workload in your MOS heavier than you expected?	M	2	1	1	1	1	8
	F	1	1	2	0	2	6
Do you need physical help to accomplish any tasks that other persons in your job are able to accomplish alone?	M	1	3	0	0	1	5
	F	2	1	0	1	3	7
Is the equipment you work with too bulky or poorly designed physically for you to handle it?	M	4	3	0	5	2	14
	F	0	0	1	1	1	3
Do you use any safety equipment or special clothing?	M	4	8	7	0	6	25
	F	1	1	1	1	3	7
Is your height a problem for performing any tasks?	M	1	1	1	0	1	4
	F	0	0	1	1	1	3
Is your size a problem for performing any tasks?	M	0	2	3	0	1	6
	F	0	1	0	1	0	2

TABLE A-9

Tabulation of Positive Responses to Question on Interview Section Entitled "Physically Demanding Task Description" by MOS and Sex

Question	Sex	05B	52D	MOS 67-	91B	98G	TOTAL
Is this task difficult for you?	M	3 of 8	4 of 9	5 of 7	4 of 84	3 of 6	19 of 38
	F	2 of 2	1 of 1	2 of 3	2 of 2	4 of 4	11 of 12
Are you tired afterward?	M	6	9	5	4	4	28
	F	2	1	3	2	3	11
Have you ever strained yourself?	M	3	3	3	1	1	11
	F	2	0	1	1	2	6
Do you know of anyone having trouble?	M	7	3	4	5	2	21
	F	1	0	1	1	4	7
Could changes be made to make this task easier?	M	2	2	1	1	2	8
	F	2	0	0	1	2	5
Would a job aid help you with this task?	M	3	8	4	4	0	19
	F	2	1	3	1	1	8
Could you use a helper on this task? task?	M	8	9	4	6	4	31
	F	2	1	2	1	4	10

APPENDIX B

Physical Tasks in Job Questions

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QUESTIONS FOR INTERVIEWS

MOS __________ Pay Grade ________ Time in Service ________ Age _____

Height ___ ft ___ in (_____ cm) Weight ______lb (_____kg) Sex _____

Unit Designation ______________________________

Position Description:

Primary Duties:

Other Duties:

What are the most physically demanding tasks in your job?

Additional questions[1]

Instructions:

Think about all the tasks you do in your present job. Consider each of the following physical characteristics and estimate how much of your job requires you to use each one in order to do the job right. In answering the questions, give the name of the task, how often it is done, how much time a day is spent doing it and what it is.

Hand-Arm Movement: How much of your job requires you to use closely guided movement of, or cooperation between, your arm and hand, or both arms and both hands? For example, what parts of your job involves taking apart or installing medium-sized components or units, or handling items in a way that requires carefully controlled movements of the hand and arm together?

Finger Dexterity: How much of your job requires you to use most of the muscles in your body to perform tasks over and over? For example, what part of your job involves withstanding muscular fatigue in the shoulders, back, and legs which results from actions like constantly driving screws with a manual tool?

Hand-Arm Strength: How much of your job requires you to use your hands and arms for things like pushing, pulling or moving medium to large sized objects? For example, what part of your job involves gripping tools, tightening or loosening nuts, bolts, or screws, or doing tasks that require more than just a little strength in your arms and hands?

Physical Effort: How much of your job requires you to use movements or positions that are tiring like working with your arms extended over your head? For example, what part of your job is done while working in cramped spaces, continuously guiding heavy objects into position, or scrambling up and down ladders, scaffolds, or stairs?

Eye-Hand Coordination: How much of your job requires you to use careful coordination between your eyes and hands? For example, what part of your job involves close movements like soldering small wires, measuring small amounts accurately, or guiding very small items into holes like threading a needle?

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[1]K. G. Koym. Development of physical demand profiles for four airman career ladders (AFHRL-TR-75-67). Brooks Air Force Base, Ohio: Air Force Human Resources Laboratory, November 1975. (AD A020 118)

Body-Coordination: How much of your job requires you to use total body control? For example, what part of your job demands good balance and ability to move quickly and easily (not necessarily using any strength), like climbing a ladder while carrying something which prevents use of hands to control your body?

Hand-Arms Steadiness: How much of your job requires a steady fixed positioning of the hand and arm? For example, what part of your job involves holding one position without shaking or wavering, like welding, or holding a pistol on target?

Precision: How much of your job requires making close or fine adjustments? For example, what part of your job demands turning knobs or dials in very small degrees, or moving levers or controls quickly and accurately, like in tuning or lining up a pointer on a line scale?

Reaction Time: How much of your job requires you to do something quickly after you get a signal by sight or by sound? For example, what parts of your job involves something like flipping a switch, pushing a lever, or turning a valve immediately after hearing a signal?

Job Standards Questions[2]

Are you strong enough to accomplish the tasks in your MOS?

If the answer is NO, explain.

Do you have enough stamina to accomplish the tasks in your MOS?

If the answer is NO, explain.

Is the physical workload in your MOS heavier than you expected?

If the answer is YES, explain.

Do you need physical help to accomplish any tasks that other persons in your job are able to accomplish alone?

If the answer is YES, explain.

Is the equipment you work with too bulky or poorly designed physically for you to handle it?

If the answer is YES, explain.

Do you use any safety equipment or special clothing?

If the answer is YES, what is the equipment and is it satisfactory?

Is your height a problem for performing any tasks?

If the answer is YES, explain.

Is your size a problem for performing any tasks?

If the answer is YES, explain.

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[2] S. J. Cook and D. R. Wilkey. Social problems of enlisted women in United States Air Force craft skills (AFIT-LSSR-6-77A) Masters Thesis. Wright-Patterson Air Force Base, Ohio: US Air Force Air University, Air Force Institute of Technology, June 1977. (AD A044 193)

Physically Demanding Task Description
(adapted from Table 3)[3]

USE ONE SHEET FOR EACH PHYSICALLY DEMANDING TASK

Task Description:

Temporal
Frequency ________(times)/________(time unit)
Duration ________(time)
Work Practices
Shift _____(Y/N) Fixed ________(period)
Rotating_______(period) ________cycle
Rest Period ______(length) ____________________(when)

Group Size ______________(number of helpers)

Forces
Lift or lower ________(Weight)
start ________(height) stop _______(height)
Push ________(amount)_______(distance) ________(time)
Pull ________(amount)_______(distance) ________(time)
Carry________(amount)_______(distance) ________(time)
Torque________(amount)_______(rotation degrees/distance)
________(amount)_______(crank revolution/direction)
Other________(type)________(amount)______(distance)______(time)

Load____________(weight)_______(distance from center of body)
_______(height from ground)

Additional questions for each task:

Is this task difficult for you?
Why does this task have to be done this way?
Are you tired afterward?
Have you ever strained yourself?
Do you know of anyone having trouble with this task?
Could changes be made to make this task easier?
Would a job aid help you with this task?
Could you use a helper on this task?

Remarks:

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[3] M. M. Ayoub, R. F. Powers, N. J. Bethea, B. K. Lambert, H. F. Martz, & G. M. Bakken. Establishing criteria for assigning personnel to Air Force jobs requiring heavy work (AMRL-TR-77-94). Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratory, July 1978. (AD A060 114)