AD-A162 781

DTIC FILE COPY

MPTL TN 86-1

NOVEMBER 1985

DOCUMENTATION OF MUSCULARLY DEMANDING JOB TASKS AND VALIDATION OF AN OCCUPATIONAL STRENGTH TEST BATTERY (STB)

David W. Robertson
Thomas Trent

MANPOWER AND PERSONNEL LABORATORY
NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92152-6800

DIRECTOR OF MANPOWER & PERSONNEL LABORATORY
NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA 92152

18 November 1985
MPL TN 86-1

MEMORANDUM FOR DISTRIBUTION

Subj: Manpower and Personnel Laboratory Technical Note 86-1

Encl: (1) MPL TN 86-1, "Documentation of Muscularly Demanding Job Tasks and Validation of an Occupational Strength Test Battery (STB)," by David W. Robertson and Thomas T. Trent

1. Many duties involved in Navy jobs require great physical effort. However, the Navy does not presently have systematic procedures for identifying such jobs or for selecting personnel capable of performing muscularly demanding duties. Enclosure (1) describes research that identified job tasks requiring exceptional strength and then developed a procedure to determine performance standards for these tasks. The researcher also developed impact analysis and discount procedures to help determine the percentages of men or women who would be excluded from muscularly demanding Navy jobs if the performance standards were adopted.

2. This research was conducted in response to a specific Navy operational concern, a request from Commander, Naval Military Personnel Command (NMPC-5), to develop occupational strength standards "to allow the Navy the best choice of personnel assignment in a time of access to a decreasing manpower pool." Previous reports described the development of the strength test battery (NPRDC Tech. Rep. 82-42) and its validation on activities with rigorous strength requirements (NPRDC Tech. Rep. 84-2). Enclosure (1) is being distributed to document work of interest to military manpower managers. Requests for additional copies should be addressed to the Navy Personnel Research and Development Center, Code 62.

Martin F. Wiskoff

Martin F. Wiskoff
Director
Manpower and Personnel Laboratory

MPL Technical Note 86-1

November 1985

DOCUMENTATION OF MUSCULARLY DEMANDING JOB TASKS AND VALIDATION OF AN OCCUPATIONAL STRENGTH TEST BATTERY (STB)

David W. Robertson
Thomas T. Trent

Reviewed by
John J. Pass
Personnel Systems Department

Released by
Martin F. Wiskoff
Manpower and Personnel Laboratory

Navy Personnel Research and Development Center
San Diego, California 92152-6800

This research was conducted in support of work unit N629808Y-WRW5043, sponsored by the Naval Military Personnel Command (NMPC-5) (Occupational Systems Department).

AD-A162781

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION	Unclassified
1b RESTRICTIVE MARKINGS	
2a SECURITY CLASSIFICATION AUTHORITY	
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
3 DISTRIBUTION/AVAILABILITY OF REPORT	Approved for public release, distribution unlimited
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	MPL TL TN 86-1
5 MONITORING ORGANIZATION REPORT NUMBER(S)	
6a NAME OF PERFORMING ORGANIZATION	Navy Personnel Research and Development Ctr, Manpower Personnel Lab
6b OFFICE SYMBOL (If applicable)	62
7a NAME OF MONITORING ORGANIZATION	
6c ADDRESS (City, State and ZIP Code)	San Diego, CA 92152
7b ADDRESS (City, State and ZIP Code)	
8a NAME OF FUNDING/SPONSORING ORGANIZATION	NAV MIL PERS CMD (OCCUP CLASS)
8b OFFICE SYMBOL (If applicable)	NMPC-5
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c ADDRESS (City, State and ZIP Code)	Washington, D.C. 20370
10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT NO	N6297084 - W12W5043
11 TITLE (Include Security Classification)	Documentation of Muscularly Demanding Job Tasks and Validity of an Occupational Strength Test Battery (STB)
12 PERSONAL AUTHOR(S)	Robertson, David W., and Trent, Thomas
13a TYPE OF REPORT	FINAL
13b TIME COVERED	FROM 10/78 TO 3/83
14 DATE OF REPORT (Year, Month, Day)	November 1985
15 PAGE COUNT	92
16 SUPPLEMENTARY NOTATION	
17 COSATI CODES: FIELD / GROUP / SUB-GROUP	05 / 09 /
18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	Muscular Strength, Occupational Classification, Test validation, Strength Testing, Job Strength, Women-men strength differences.

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A strength test battery (STB) was validated on several muscularly demanding occupational tasks of common shipboard and occupation-specific duties. A dynamometer-measured armpull was the best correlate of the STB. An "impact analysis" procedure was also developed so that management could determine the effect of a STB cut-score on the percentage of men or women that would be excluded from entering a particular job.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS
21 ABSTRACT SECURITY CLASSIFICATION	UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL	David W. Robertson
22b TELEPHONE (Include Area Code)	(619) 225-7551
22c OFFICE SYMBOL	62

DD FORM 1473, 84 JAN

83 APR EDITION MAY BE USED UNTIL EXHAUSTED
ALL OTHER EDITIONS ARE OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

SUMMARY

Problem

Many shipboard duties and the specific duties of some Navy jobs require great physical strength. However, Navy enlisted selection and classification decisions do not presently take these strength requirements into account. Without methods to measure the physical ability of men and women to perform to specified strength standards, personnel may be assigned to jobs in which they cannot fully perform all tasks, or they may risk injury by attempting tasks beyond their strength.

Objective

The objectives of this research were to (1) identify muscularly-demanding tasks, (2) develop a procedure to identify particular tasks and their performance measures as criteria for validation of a basic strength test battery (STB), (3) develop a procedure to determine task performance standards, and (4) develop a procedure to determine the percentage of men or women excluded by these standards from entering a given muscularly demanding job.

Approach

There were three phases to criterion development of muscularly demanding tasks: (1) design and administration (by mail to incumbents) of a special survey to identify and classify the job tasks (shipboard tasks to be analyzed were identified by Congress), (2) follow-up visits to ships and activities to take objective measurements and to determine performance standards, and (3) administration of criterion performance tests (designed from the selected tasks).

The survey design incorporated a taxonomy of 11 basic body efforts (e.g., lift, carry, push). Incumbents were asked to classify muscularly demanding tasks of their jobs into these categories. Incumbents were also asked to identify (1) the most muscularly demanding tasks, and (2) the muscularly demanding tasks that all job incumbents were expected to be able to perform.

Because objective, muscular-demand performance standards do not exist as official policy, standards for tasks were developed in terms of weight (force) carried or lifted for a given distance within a specified time. These three basic variables, force, distance, and time, were then entered into a work output formula to reduce the standard to a single objective value.

The approach included evaluation of test fairness and development of alternate procedures to determine the percentage of men or women excluded from entering a job, given a criterion performance standard, an STB cut-score, and expected gains from physical conditioning.

Findings

1. Three basic body efforts--lift, carry, and pull--accounted for 84 percent of all tasks for common shipboard jobs.

2. On the average, Navy men performed much better than Navy women on the criterion tasks.

3. Many of the STB components correlated substantially with performance on common shipboard and occupation-specific tasks. Static strength measures such as armpull were best for measuring capability to handle heavy material as documented in the present study. But a review of the literature indicated dynamic measures such as calisthenics and swimming were best for measuring capability to perform rigorous body movement. Combining pairs of STB components (for example, armpull plus armlift) raised the validities a few correlation points for each gender subgroup.

4. Statistical tests of selection fairness by one procedure investigated indicated that separate regression lines for each gender subgroup had to be used to determine STB cut-scores. Another procedure assessed was found less severe on the percentages of women excluded than was the regression line technique.

Conclusions

1. A survey and a data base of muscularly demanding tasks were quite useful as starting points to identify specific criterion tasks and can be further useful in other projects that address physical demands.

2. Simulated tests of muscularly demanding tasks have some advantages over administration of the actual task aboard Navy combat ships. The simulated tests are safer and more efficient. They did not require use of operational equipment, and they did not interfere with operational crews.

3. An STB is a valid indicator of the capability to perform muscularly demanding shipboard and occupation-specific tasks. Some of the best correlates of shipboard performance are armpull, ergometer, and body weight.

4. Procedures to determine STB cut-scores, however, vary in percentages of personnel excluded. One method, the rectangular one, is less severe in percentages of women excluded and, thus, may be the most useful to implement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem

Many Navy tasks require substantial muscular capability, but Navy enlisted selection and classification decisions do not at present take into account these great strength requirements. Without methods to measure the physical ability of men and women to perform to specified standards, personnel may be assigned to jobs in which they cannot fully perform all tasks, or they may risk injury by attempting tasks beyond their strength. Given the substantial differences in strength between men and women, (Laubach, 1976; Robertson, 1982), the problem has become more salient in the Navy as increasing percentages of women are assigned to muscularly demanding jobs.

Background

The requirements of muscularly demanding Navy jobs vary extensively. Some jobs require handling heavy components of machinery or weapons systems (in the typical shipboard environment for example), with relatively little body movement. Others require rapid movement of the body through extreme and hostile environments (such as the work of the underwater demolition team). Because of this variety, a "strength aptitude" test was needed that was versatile enough to predict a wide range of muscular capabilities. A basic strength test battery (STB) was developed to measure strength aptitude through this wide variety of muscular capabilities (Robertson, 1982). The dynamic strength measures (e.g., calisthenics type) of the STB were the best predictors of job tasks involving rapid movement of the body (such as underwater demolition team training, Robertson & Trent, 1983). However, in private industry the muscular capability to handle heavy materials was predicted with a simple, single, static type (armpull dynamometer) measure (Arnold, Rauschenberger, Soubel, & Guion, 1982).

Management Direction

Several realities of strength testing shaped unusual approaches to project development. First, because of serious safety considerations, individual testing requirements, and extensive use of operational sites and equipment, sample size had to be minimized. Second, because of a large number of criterion tasks with widely differing characteristics (some were common shipboard tasks, while others were unique to specific occupations), it was necessary to limit each job to one criterion task. Third, the population of interest, men and women, had widely separated strength scores, requiring separate administration to these gender subgroups and separate analysis, but requiring application of common performance standards to ensure that the tests were "gender free."

The selection of criterion tasks was influenced by particular concerns. Criteria for common shipboard duties were selected in direct response to the concerns of the Congress. They wanted to know the capabilities of men and women, particularly of women, in the shipboard environment to: (1) extricate injured personnel, (2) control fire hose nozzles, and (3) move through watertight doors and scuttles. There was no comparable concern, however, for selection of criterion tasks for particular occupational specialties, and there was no official document that specified job criteria or performance standards. Thus, procedures had to be developed to (1) identify muscularly demanding occupations, (2) select a criterion task for each of those occupations, and (3) determine a performance standard for each criterion task. These procedures were developed as a cooperative effort between the advisory group steering the research project and the research staff. Approximately one fourth of the Navy's total of about one hundred ratings (occupational specialties) were selected as candidates for strength standards, and seven of these ratings were selected as "lead" ratings in the validation phase of the project. These ratings were: boatswain's mate (BM), hull technician (HT), aviation ordnanceman (AO), electrician's mate (EM), and the three ratings of the aviation boatswain's mate--fuels (ABF), aircraft handling (ABH), and equipment (ABE). These lead ratings were selected because they represented labor-intensive jobs in the fleet and because their tasks represented a great variety of basic body efforts (carrying, pulling, torquing, etc.).

Another primary concern of management was the prospect that large percentages of women might be excluded from a job, even if no men or only a small percentage of men were excluded, given the large differences in strength between the gender groups (Laubach, 1976; Robertson, 1982). Navy military personnel managers were particularly interested in a procedure that would anticipate strength gains from physical conditioning, either by a formal conditioning program, or from muscularly demanding experiences on the job.

Cooperation Among Services

Each military service has related projects to develop and validate a basic STB and to identify muscularly demanding tasks for that service branch (e.g., McDaniel, Skandis, & Madole, 1983; Myers, Gebhardt, Crump, & Fleishman, 1984). The Department of Defense administers military entrance processing stations in which the procedures for processing an applicant into any service are standardized wherever feasible. Because each service laboratory's research staff understands that common components of an STB would be desirable, there have been frequent, informal interactions and workshops among them. For example, one particularly cooperative effort involved an Air-Force-developed incremental lifting machine (ILM) that was shared with and evaluated by the other services. Also, a Joint-Services Physical Requirements Working Group was convened in 1983 and hosted by the Assistant Secretary of Defense (Accessions Policy section of the Manpower, Reserve Affairs, and Logistics--Military Personnel and Force Management), so that management and research representatives of the various services could interact.

Objectives

The objectives of this research were to (1) identify and classify muscularly-demanding tasks, (2) develop a procedure to identify particular tasks and their performance measures as criteria for validation of a basic strength test battery (STB), (3) develop a procedure to determine task performance standards, and (4) develop a procedure to determine the percentage of men or women excluded by these standards from entering a given muscularly demanding job.

APPROACH

Criterion Development

A Navy-wide mail survey to job incumbents and follow-up site visits were used to develop a large variety of performance criteria. The survey was designed to address the following questions: (1) What are the muscularly demanding tasks? (2) what basic body efforts are most frequently involved in Navy kinds of muscularly demanding tasks? and (3) how many lost work days do incumbents report?

Survey Instrument

Although the exact weight of various objects can be readily found in technical manuals and equipment specifications, the precise procedures for handling them are not available (number of persons required, transported by carrying or dragging, etc.). Thus, a special occupational inventory to document muscularly demanding tasks and the injuries therefrom was designed and mailed Navy-wide in two forms (see Appendix A). One form was mailed directly to a sample of job incumbents. A similar survey was mailed to command representatives of all types of Navy ship and shore units to document common tasks at the command level, perhaps across several occupations).

The survey included items of information about the amount of force (in pounds) exerted on an object to move it, the frequency and duration of performing a task, and whether a task was muscularly difficult due to restricted space, grip, or reach. To facilitate communication with the incumbents, a taxonomy of 11 basic body efforts (BBE) was developed, and a few simple examples were provided with each BBE (see p. A-3).

Sample

Objective data regarding muscularly demanding tasks are essentially nonexistent. Thus, data were collected initially by mail from job incumbents who identified muscularly demanding tasks and procedures, and then the initial survey was followed up with field visits to the incumbents for further elaboration and objective force measurements. A relatively small sample size in each occupation (each of about 100 ratings and 25 of 990 naval enlisted classification codes (NECs) was specified for three reasons: (1) For initial identification of the tasks, the survey instrument had to be largely "open ended" and was therefore, very time-consuming to the respondent in the fleet; (2) a low return rate was expected because the survey was time-consuming; and (3) there were few women in the occupations of primary concern, those with substantial muscular demand.

For each occupation (rating or NEC), 45 men and up to 45 women (if available) were randomly selected from personnel in pay grades E-3--E-5; additional personnel were taken from E-6--E-7 if a total sample of 45 each of men and women was not achieved in the lower grades. The command form was sent to 1862 different units (see Table 1).

Table 1
Results of Survey Instrument Mailing

Respondent	Surveys Mailed N	Surveys Returned and Usable for: Task Documentation or Injury Experience N	%	Task Documentation Only[a] N	%
Individual Incumbents	7281	2386	32.8	1429	19.6
Commands	1862	--	--	455	24.4

[a]To be usable for task documentation, the open-ended description had to be adequate to (1) identify a specific object handled and related to the particular occupation, and (2) determine what was done with the object.

Injury Experiences

A preliminary and limited analysis was performed on part of the survey regarding injury experiences (question 5, page A-5). First, each occupation was identified with one of two groups--a muscularly demanding one (e.g., mechanical, technical, construction) and a nonmuscularly demanding one (e.g., administrative, communications). Then the percentages of men and women indicating muscle or bone discomfort in each of these two kinds of occupational groups were tallied. In this small sample, as indicated in Figure A-1, both men and women in the muscularly demanding group had higher frequencies of sick call and lost work than men and women in the other group.

Criterion Task Selection

After the survey data were collected and reviewed, job tasks were chosen from them as criterion tasks for ratings or common shipboard duties. It was necessary to minimize the number of criterion tests because of the difficulties involved with this unique kind of testing, including extensive use of operational or training equipment, time-consuming and individual testing procedures, need for a very large test administration staff, and safety considerations. A distinction was made between two kinds of tasks, called alpha and bravo, to ensure the appropriate mix of both technical and muscular capabilities. An alpha task was defined as a task that all members entering a work group are expected to perform, and that all members must be capable of performing. It represents the capability to perform all other alpha tasks. A bravo task was defined as a task that some members of the work group, but not all, must perform. All bravo tasks are more demanding than alpha tasks. It would reduce effective use of personnel resources if a bravo task were identified as the criterion task for a work group.

Eighteen criterion tasks were selected for 16 ratings, and 16 tasks were selected for shipboard duties. (Some jobs had two or three criterion tasks, while two or three other jobs had the same criterion task.) The criteria for shipboard duty were selected in direct response to congressional interest (concerning capability to perform fire fighting, movement through watertight doors and scuttles, and extrication of injured personnel). The criteria for ratings were selected on recommendations of incumbents during field visits, which were employed to (1) contact the job incumbents as the most knowledgeable source of information, (2) identify the objects in each work group that required muscular efforts to lift, carry push/pull, or torque, (3) determine whether each muscular application was a type alpha or bravo task, (4) select an alpha task that best represents the capability to perform all other alpha tasks identified in that work group and is feasible to administer, and (5) develop procedures for establishing objective standards (i.e., weight times distance per unit of time) for minimum allowable performance by observing the incumbents' performance. The research staff visited several types of ships (except submarines) and carrier-based squadrons. Data gathered from job incumbents varied greatly, depending on the type of effort required. Incumbents were much more accurate at estimating the weight of an object lifted or carried than in estimating the force needed to push or pull it.

Procedures to Establish Objective Standards

Because few objective performance standards exist (none for muscularly demanding tasks), it was necessary to develop a procedure to establish them. First, incumbents identified an alpha task as the criterion for each occupational specialty or type of shipboard job. Then the procedure involved six parts: (1) an observation of task performance or a description of the task by incumbents, (2) measurement by dynamometer of the force needed to lift, carry, push, pull, or torque an object, (3) measurement of the distance and direction that the object was moved, (4) identification of the grip points at which the object was handled, (5) determination of the minimum time to accomplish the task productively, and (6) design of a work output (WKO) format by which a task performance standard could be simply specified. This WKO format was based on the data obtained for three variables (force, distance, or duration).

The data provided by incumbents was used to develop criterion tests, administration procedures, and task performance standards for occupation-specific tasks (see Appendix B) and for common shipboard tasks (see Appendix C). The performance standards derived from contact with small numbers of incumbents were needed to demonstrate (1) an objective procedure to specify performance standards, (2) the versatility and validity of the STB across a wide range of muscularly demanding criterion tasks, and (3) the development of an "impact analysis" procedure.

The criterion tests and performance standards for the occupation-specific jobs are presented in Table B-1 and for shipboard tasks in Table C-2. For example, as shown in Table B-1, applying the standard to the acetylene bottle carry, carrying the required weight load of 133 pounds up 7 steps within 25 seconds, equals the standard WKO of 5.32. For each common shipboard task (Table C-2), the performance standards (all in seconds) were developed for two different conditions--routine and operational/emergency--depending on the condition under which the it might be performed. For example, an emergency P-250 pump might have to be carried very rapidly to the scene of a fire or flooding emergency (45 seconds), or the pump might be carried routinely to a shop for maintenance (240 seconds).

Job Task Data Base

After a relatively small number of tasks were selected for criterion tests, all of the data (several thousand tasks) submitted by incumbents from the mail survey were inspected to develop a data base for muscularly demanding job tasks. The detailed procedures used to determine the tasks included in the data base are presented in Appendix D. After the data bases were created, computer programs were written that would provide a capability to retrieve task data by any element of interest, for example, by occupation, BBE type, ship type, or grip difficulty. Frequency counts by BBE category for deploying commands were tallied to provide a distribution profile.

Sample Format. Table 2 provides examples from the data base for five ratings. As indicated, the data were retrieved first by rating, and then rank-ordered on one-person force estimates. The HT rating displays nine tasks, five of which involve carrying or lifting heavy objects. The heaviest object (first on the list) was carrying while walking 150-pound oxygen or acetylene bottles. Table 3 provides extracts for seven types of ships, retrieved first by ship type, and then rank-ordered on a derived variable, weighted sum (WTSUM-see Appendix D for calculation procedures). The removal of a davit (WTSUM = 300) appears to be the greatest effort of an entire work group aboard submarines.

Distribution of Basic Body Effort (BBE). The distribution of the 605 tasks described by unit representatives of 225 deploying commands (mostly ships), is shown in Figure 1. In common shipboard duties, most muscularly demanding tasks were BBE types 1, 2, and 6 (lifting, carrying, and pulling)-- 84 percent of all tasks reported. Thus, very few common shipboard duties include running (BBE3), but some other occupations do involve rapid or rigorous movement of the body, such as the work of underwater demolition teams (Robertson & Trent, 1983), and part of the work of the ABE--running on the flight deck to reposition a launch bridle. The muscular demands, however, appear to ensue primarily

Table 2

Documentation of Muscularly Demanding Tasks (Brief Format) by Rating and Incumbents' Force Estimate

Rating	Task (Q1)	Basic Body Effort (BBE, Q17)	1-Person Force Estimate (Q4B)	Incumbent's Estimate of Physical Demands (Q3)[a]	Workday Task Performed Per Year (Q24)	Total Minute Task Performed Per 8 Hours (Q23)
Hull Maintenance Technician (HT)	Oxygen/acetylene bottle; shop to stowage rack	Carry-walking	130	2	52	15
	50-lb CO2 bottle caps; remove	Turn-lever	130	5	48	20
	Argon gas bottles; onto welding machine	Lift-without carry	100	3	20	5
	Half-inch steel plates; move	Lift-without carry	100	5	365	-
	Firemain valves; install	Lift-without carry	100	5	25	420
	Welder; across length of ship	Push-distance	100	3	100	10
	Ballast-tank wheel; open	Turn-wheel	100	2	365	240
	Welding leads; carry shop to job	Carry-walking	50	4	150	120
	Bull-dog shears; cut sheet metal	Squeeze	50	2	100	15
Boatswain's Mate (BM)	Vehicles; down tank deck	Push-distance	200	3	50	480
	Stern anchor brace	Turn-wheel	150	3	150	2
	5 gallon cans (2) of red lead	Carry-running	125	3	1	5
	King post; underway replenishment	Lift-without carry	100	3	15	3
	Handling lines	Pull	100	2	100	90
	Winch; handcrank	Turn-lever	100	3	5	240
	5 gallon paint cans; storage to deck	Carry-walking	50	3	30	240
Aviation Structural Mechanic--Hydraulic (AMH)	Hydraulic test stand; to aircraft	Push-distance	150	3	100	20
	Tool boxes; shop to aircraft	Carry-walking	120	5	150	20
	Wrench; brake assembly bolts	Turn-lever	100	2	24	17
	Brake assembly; overhaul	Lift-without carry	75	3	100	60
	Handle hydraulic; jack aircraft	Push-repetitive	50	4	100	20
Machinist's Mate (MM)	Main steam valve; open/close	Turn-wheel	140	2	-	15
	3 freon bottles; shop to job	Carry-walking	110	2	20	120
	Pumps and valves; overhaul	Lift-without carry	100	2	225	15
	Rope; on pully lift	Pull	100	2	10	5
	Machinery; around shop	Push-distance	80	1	100	90
Electrician's Mate (EM)	Wrench; mounting bolts on motor	Turn-lever	250	5	300	60
	Shore power cables; install	Pull	180	3	4	200
	Vanaxial fans; position	Push-distance	150	2	12	10
	Motor; to workbench	Carry-walking	150	4	30	120
	Magnet wire on spool; rewind	Lift-without carry	100	3	100	4
	Mallet; remove endbell	Swing-repetitive	100	2	50	180
	Pump valves; open/close	Turn-wheel	80	4	250	60
	Shaft bearings; remove	Pull	75	4	30	60

Note. Questions (Q) refer to items from Rating/NEC-Specific questionnaire (brief format, see Appendix A, p. A-7).

[a]In moving the object (Q3), the code number that described the physical demands of the task to the job incumbent were: (0) So easy that it requires practically no effort at all; (1) Requires some effort, but still quite easily within capabilities: (2) Although demanding, is still within capabillities: (3) Pushes the very limits of capabilities, barely able to move the objects(s): (4) Sometimes exceeds strength capabilities: (5) Usually exceeds strength capabvilities (see Appendix A, p. A-10).

Table 3

Documentation of Muscularly Demanding Tasks From Unit Command Detailed Format by Ship Type and Estimated Work Group Effort

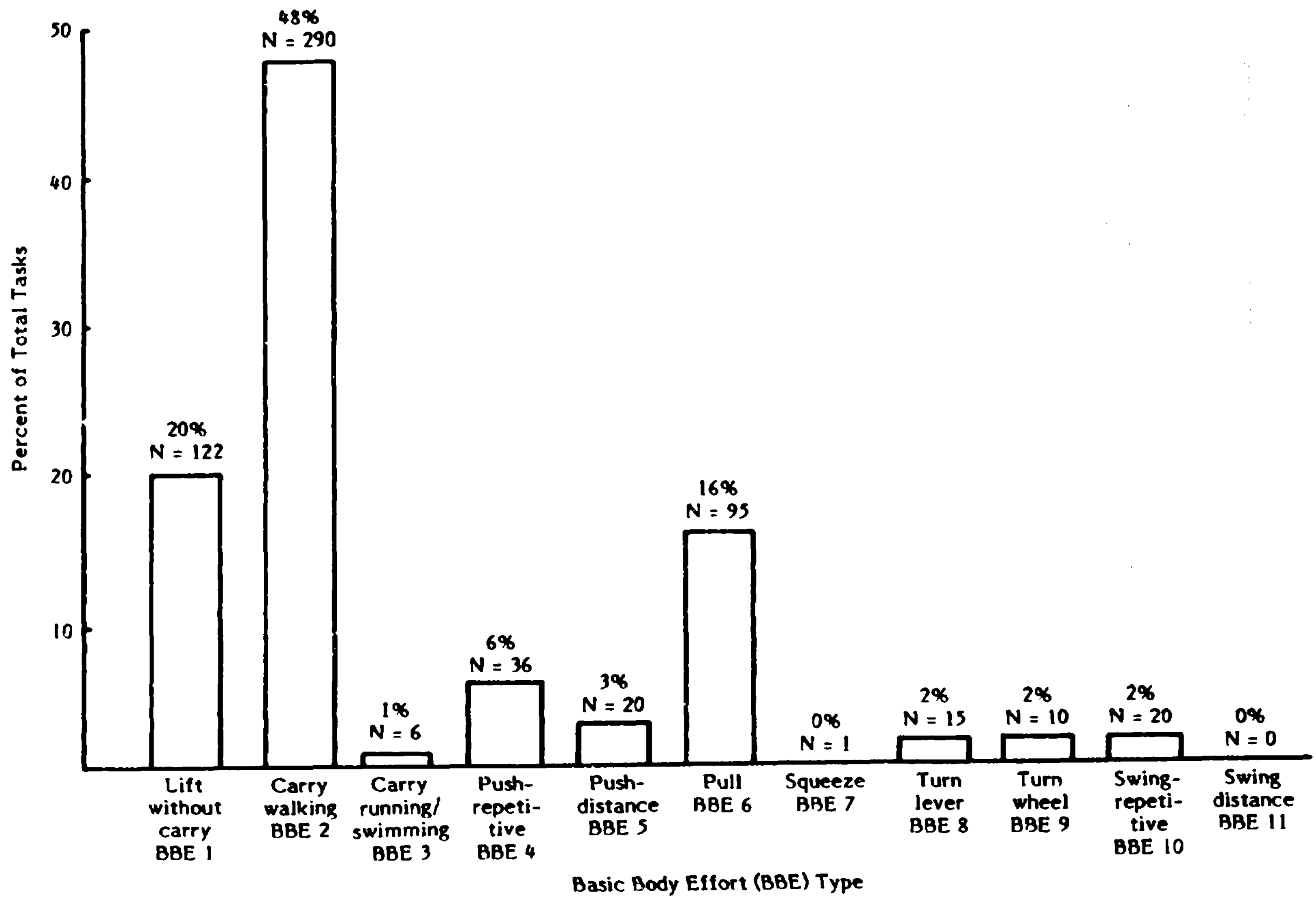
Task (Q1)	Basic Body Effort (BBE, Q17)	1-Person Force Est. (pounds, Q38)	Percent of the Workgroup Performing by Effort Code[a]: Little Effort (0)	(1)	(2)	(3)	(4)	Exceeds Capability (5)	WTSUM[c]	Difficulty of Task Because of[b]: Grip	Restricted Space	Reach	Ship/Command Type
Sub davit; remove	Lift	100	0	0	33	34	33	0	300	0	0	1	Submarine
Stores; onload replenishment	Carry—walking	50	0	0	50	10	40	0	290	2	2	1	
MK48 guidance wire dispenser; install	Lift	120	0	0	50	25	15	10	285	1	0	0	
Cruise boxes; onload/offload	Carry—walking	80	0	5	40	40	10	5	270	2	2	2	
Pump motors; rig for offload	Pull	100	0	0	50	40	10	0	260	1	0	1	
MK48 torpedoes; load	Pull	100	0	0	50	50	0	0	250	3	0	2	
Feed system valve; open/close	Turn—wheel	100	0	5	50	40	5	0	245	2	2	3	
TDU weights; onload	Carry—walking	80	0	10	60	20	10	0	230	1	2	1	
10 lb sledge; loosen nuts turbine gen.	Swing—repetitive	10	5	20	75	0	0	0	170	2	0	0	
Mooring lines; rig	Pull	150	4	26	70	0	0	0	166	1	2	1	
60KVA generator E2 aircraft; replace	Lift—without carry	90	0	0	0	50	0	50	400	0	0	0	Squadron
Radar amp E2B aircraft; replace	Lift—without carry	95	0	0	0	67	0	33	366	3	0	1	
Tripod jacks; manually operate	Push—repetitive	100	0	0	50	0	0	50	350	3	3	2	
Cruise boxes of parts; lift—carry	Carry—walking	125	0	0	0	80	20	0	320	1	1	2	
L-speed drive, E-gen. on Y79-8; replace	Lift—without carry	150	0	0	0	90	10	0	310	1	0	0	
Ejection seat H7; F4 aircraft to deck	Lift—without carry	75	0	17	33	17	0	33	299	0	0	0	
Sparrows, AIM9 and MK82 bombs; load	Lift—without carry	125	0	10	40	20	10	20	290	1	0	0	
AIM-7 missile; ground to aircraft	Lift—without carry	130	0	0	70	20	10	0	240	3	1	2	
A7E canopy assembly; reinstall	Lift—without carry	100	0	0	75	25	0	0	225	0	1	2	
F4N aircraft wheel; tire assembly	Lift—without carry	135	0	0	75	25	0	0	225	0	1	3	
S3A air component; run	Carry—running/swim	80	0	5	75	15	5	0	220	1	0	1	
Hangar doors; open/close	Push—distance	150	0	5	89	5	1	0	202	3	2	2	
BRU11 bomb rack; reinstall	Lift—without carry	110	10	40	20	30	0	0	170	2	3	1	
2 cans paint; 1500 ft.	Carry—walking	140	0	0	0	50	50	0	350	1	2	3	Carrier
Fueling probe head; to fuel station	Carry—walking	175	0	0	20	80	0	0	280	0	2	2	
Anchor chain stopper	Lift—without carry	100	0	30	40	20	10	0	210	3	2	1	
Food supplies; onto conveyor	Lift—without carry	50	0	33	45	11	11	0	200	3	2	2	
Highline rig; personnel transfer	Pull	300	0	30	50	10	10	0	200	2	2	2	
Towing bridge; rig	Carry—walking	100	0	0	20	50	30	0	310	3	0	3	A[illegible]hibious
Shore power cables; rig	Pull	125	0	1	65	30	10	4	281	2	2	2	
Ships boats; hoist and lower	Lift—without carry	100	0	0	60	30	10	0	250	0	0	0	
Ammo; lift to magazine storage	Lift—without carry	80	0	5	50	40	5	0	245	2	2	1	
6 in. high psi boiler steam valve; open	Turn—Wheel	75	10	20	30	40	0	0	200	1	0	1	
5 gal paint cans; pier to locker	Carry—walking	55	0	0	50	25	20	5	280	0	2	2	Cargo
6-9 in. hauser line	Pull	100	0	50	25	15	5	5	190	1	3	1	
Unrep station; rig-unrig.	Lift—without carry	75	40	24	20	10	5	1	119	2	3	1	
Stores; palleting	Lift—without carry	55	20	70	10	0	0	0	90	1	3	1	
Main steam stop valve; open	Turn—wheel	125	0	0	10	40	25	25	365	3	1	1	Cruiser
P250 gas pump; to pier rescue	Carry—walking	80	0	5	75	5	10	5	235	2	2	1	
5 in ammo; store/load	Carry—walking	60	0	10	90	0	0	0	190	3	2	1	
Stores; working party	Carry—walking	50	10	25	60	4	1	0	161	1	2	2	
Fueling rig; to ship from delivery ship	Pull	100	0	0	0	2	98	0	398	3	2	3	Destroyer
Wrench; casting bolts, mainfeed pump	Turn—lever	250	0	5	50	25	10	10	270	1	0	0	
5 in/54 projectiles; lift to breach	Lift—without carry	74	0	10	20	70	0	0	260	1	0	0	
5 in nylon mooring lines	Pull	130	0	0	50	50	0	0	250	1	0	3	
RAS kingpost; underway replenishment	Carry—walking	125	0	0	90	10	0	0	210	3	0	2	
5 in/54 projectiles; from pier to mag	Carry—walking	72	5	15	60	10	10	0	205	2	2	3	
10 in pneumatic grinder; lift/hold	Lift—without carry	20	0	5	20	0	70	0	325	1	1	0	Repair
Steel plating; move	Push—repetitive	200	0	0	75	20	5	0	230	1	2	2	
Shore power cables	Pull	100	0	0	90	10	0	0	210	2	2	3	

Note. Questions (Q) refer to items from Common Tasks Survey questionnaire (see Appendix A, pp. A-15 to A-19).

[a]Strength differences required among performing workgroup; little effort (0); some effort (1); very demanding but within capabilities (2); requires maximum capabilities (3); sometimes exceeds capabilities (4); usually exceeds capabilities (5) (see Appendix A, Q4, p. A-17).

[b]This task is difficult to perform partly because of the grip (Q18), cramped/restricted space (Q19), reach (Q20); ending; (0) very; (1) fairly; (2) slightly, (3) not at all (Questions 18-20 in Appendix A, p. A-13).

[c]Weighted sum (WTSUM) equals the sum of the six products of each numerical value of effort code (0-5) times the percent numerical value of workgroup performing (0-100) at that effort code.



Note. Tasks (N = 605) from 118 ships, 48 squadrons, 42 submarines, and 17 other deploying units; see Appendix A, p. A-3 for definition and examples of BBEs.

Figure 1. Distribution of shipboard and military tasks with greatest muscular demands by type of BBE.

from the object moved (e.g., diving equipment or launch bridles) rather than from the running, itself.

Validation of Strength Test Battery (STB)

Criterion Variables

Criterion tasks, selected as described previously, were developed into 18 performance tests (variables, hereafter termed "V," 10-27) for specific occupations and 16 (unnumbered) tests for common shipboard jobs (see Table 4). Descriptions of equipment and detailed procedures for administration of these tests are presented in Appendices B and C.

Basic Strength Aptitude Predictors

Basic research has been conducted to measure general physical fitness and strength. For example, Fleishman (Fleishman, 1964; Fleishman, Dremer, & Shoup, 1961) identified nine basic elements of fitness and strength, including three primary strength factors: dynamic strength, static strength, and explosive strength. Dynamic strength involves movement or support of the weight of one's body, as exemplified in pull-ups and push-ups. Static strength involves the exertion of force against a heavy or immovable object, as in medicine-ball putting or in measuring handgrip strength with a dynamometer. Explosive strength involves a burst of effort to jump or project the body or some object as far as possible, as in the broad jump, the shuttle run, or the softball throw.

Few studies, however, have demonstrated the relationship between basic strength measures and specific job tasks. Two examples of the kind of work needed include a project reported by Tenopyr (1977), who used the Fleishman tests to develop predictors for a telephone line installer job that required pole-climbing, ladder-positioning, and balancing abilities, and a study by Davis (1976), who used strength tests to predict performance of fire fighting tasks.

A basic STB was developed at the Navy Personnel Research and Development Center to measure strength aptitude through the wide range of muscular demands of Navy tasks (Robertson, 1982). The original STB comprised 14 tests. Six were anthropometric--height, weight, and skinfold measures at four sites. Eight strength tests measured three types of strength--static (3), dynamic (4), and power (1). The three static strength tests were handgrip, armpull, and armlift, which were measured by dynamometers. The four dynamic strength tests were sit-up, push-up, pull-up, and bent-arm hang. The power test measured upper torso power, using a hand-cranked ergometer to simulate job tasks that involve a turning or pumping activity (of a wheel, lever, or handle) at maximum effort for brief periods.

The selection of several of the tests in the STB was influenced by their high positive or negative loadings of Fleishman's (1964) dynamic and static strength factors. Two of these tests loaded highest on the static strength factor--handgrip (.72) and armpull (.71), and three loaded highest on the dynamic strength factor--pull-up (.81), push-up (.74), and bent-arm hang (.73). Body weight loaded -.43 on the dynamic strength factor and .70 on the static strength factor.

In the present research, the original STB was administered except for the bent-arm hang test, with the shipboard tasks. For the occupation-specific tasks, however, most of the anthropometric and dynamic measures were eliminated from the STB because they indicated little promise, and the USAF-developed ILM was added (see Table 4). Appendix

Table 4

List of Variables

Predictors	
Tests of strength aptitude (STB)	Tests of strength aptitude (STB)
1. Armpull	8. ILM-press[a]
2. Armlift	9. ILM-elbow[a]
3. Ergometer	- Handgrip (HGRIP)[b]
4. Height	- Push-up (PSHUP)[b]
5. Weight	- Lean body weight (LBW)[b,c]
6. Sit-up	- Percent fat (PCFAT)[b,c]
7. ILM-jerk [a]	

Criteria

Occupation-specific tests		Tests of common shipboard tasks
10. Drop-tank carry	(AD)	Movement through watertight door
11. Tow-bar run (clear)	(ABH)	8-dog
12. Tow-bar run (across cable	(ABH)	10-dog
13. Fuel probe/acetylene bottle carry	(BM, HT)	Single-lever (normal)
14. Crucible pour	(ML)	Single-lever (tight)
15. 5-gallon can carry (ladder)	(BM)	Scuttle
16. Equipment carry (ladder)	(Aviation ratings)	Movement through stretcher carry
17. Acetylene bottle carry (ladder)	(HT)	Level
18. Bomb load	(AO)	Up ladder
19. Canopy raise (1-arm)	(AME)	Down ladder
20. Canopy raise (2-arm)	(AME)	Shoulder drag
21. Rope pull (160 lb)	(BM)	Fire fighting
22. Rope pull (60 lb)	(BM)	1 1/2" nozzle
23. Cart pull (75 lb)	(AS)	2 1/2" nozzle
24. Cart pull (45 lb)	(AS)	Fire hose carry
25. Fuel hose drag (105 lb)	(ABF)	Down ladder
26. Power cable rig (80/100 lb)	(EM)	Up ladder
27. Bolt Torque	(ABE)	Emergency pump (P250) carry
		Carry down ladder
		Carry up ladder
		Pull start

[a]ILM--USAF-developed incremental lift machine (see Appendix B).

[b]Part of original STB (Robertson, 1982), administered with shipboard tasks but not with occupation-specific tasks.

[c]Estimated from skinfold measures (see Robertson, 1982).

B presents the detailed procedures for administration of 9 tests in the STB (variables 1-9, Table 4).

Sample

Shipboard Tasks. Because of congressional interest, the shipboard tasks were tested first. Considerable difficulty was experienced in acquiring adequate samples, especially of women subjects, from shore bases. One shore intermediate maintenance activity (SIMA) was most supportive and provided samples of 24 men and 21 women for initial administration of both the STB and the criterion shipboard tasks. Although these samples were relatively small, they provided a clear indication of the relationship of the STB with the criterion tests.

Occupation-Specific Tasks. Because of the great difficulties encountered in acquiring adequate performance samples for the shipboard tasks, coordinating operational testing sites aboard ship with fleet commanders, and maintaining bus schedules, different strategies were employed to design and administer the STB and performance tests for the occupation-specific criterion tasks. Tests were administered at the Orlando Recruit Training Center (RTC), using recruit subjects in the latter half of their training. Sample sizes were 274 men and 259 women.

Test Administration

During the shipboard task test administration, the individual, time-consuming, muscularly demanding nature of the testing for a relatively small number of test subjects required a relatively large number of test administrators and safety monitors--approaching a ratio of about one to one. Access to test sites and subjects were so limited that improvements were incorporated for the occupation-specific tests: (1) Criterion task tests were sampled or simulated, equipment was specially designed, and equipment was transported to or constructed on site at Orlando; (2) sample size was substantially increased by using available recruits; (3) lack of experience on the job tasks, between men and women, was matched by using recruits; and (4) accident rate due to fatigue or nonfitness was minimized by using only recruits who were in the latter half of their training, having completed most of the physical conditioning program.

Test Sites. In an effort to demonstrate maximum face validity, most of the shipboard criterion tests were administered in the actual operational environment, aboard combat ships (a destroyer, a frigate, and an assault helicopter landing ship) and at a fire fighting school. Subjects were drawn from the SIMA so that the ships' crews would not be bothered or involved in the testing, and so that all test subjects would be similarly inexperienced during the 4-day testing period.

STB Correlates. Many STB components correlated with criteria for common shipboard tasks (see Tables C-3 and C-4). For example, the static measures of armpull (ARMPL) and handgrip (HGRIP) correlated respectively for men .62 and .69 on the criterion task of the capability to move through an 8-dog watertight door, and for women .65 and .55. Tables C-3 and C-4 also present the means and standard deviations of the performance groups for both the STB components and the criterion tasks. The average scores of the men and women are widely separated--a typical finding between gender subgroups (see also Robertson, 1982).

The best correlate for both men and women was the static measure, ARMPL, followed by the power measure, ergometer (ERGOM). When two measures (e.g., armpull plus armlift--see column PF + LF of Tables C-3 and C-4) are conbined into a simple, unit-weighted composite, the correlation coefficients typically increase slightly. For example, for the total stretcher carry up and down a ladder, the separate correlations for ARMPL and ARMLF and their composite (PL + LF) increase respectively for men from .64 and .60 to .74, and for women from .79 and .56 to .81.

Total body weight (see WT column of Tables C-3 and C-4) also correlated with many criterion tasks, and additional, time-consuming efforts to take skinfold measures and calculate the separate components of lean body weight (LBW) and percent fat (PCFAT), did not contribute much improvement. The dynamic measures in the STB, pull-up, sit-up, and push-up, correlated poorly with the criterion tasks, although they have been found in another study to predict rigorous body movement (Robertson & Trent, 1983).

Combining the two disparate gender subgroups into a total sample yielded substantially increased correlations (see Table C-5). The static measures typically increase to the .50s-.80s in correlation values. For example, the relationship of ARMPL to the criterion task of movement through a scuttle increases from .43 and .27 for men and women respectively (Tables C-3 and C-4) to .53 (Table C-5) when the gender subgroups are combined.

Analysis

For the occupation-specific testing at Orlando, Florida, raw score data were used for STB measures (V1-V9, see recording procedure in Appendix B) and WKO score data were used for criterion tests (V10-V27, see Table B-1). Means, standard deviations, and intercorrelations were calculated separately for men and women samples. The ratio of women's to men's scores and the Tilton (1937) percentage of overlap were also calculated. In determining the concurrent validity of the STB on criterion performance, Pearson correlation coefficients were calculated between those two kinds. A comparison was made among three kinds of coefficients: simple correlations (one component of the STB and one criterion test), a unit-weighted composite (two or more STB components and a criterion test) and multiple regression application (optimal weighting of two or more STB components and one criterion test). For a determination of selection fairness between the regression lines of the gender subgroups, the multiple regression analysis procedures of Bartlett, Bobko, Mosier, and Hannan (1978) were employed. Extensive work was also undertaken to develop impact analysis and discount procedures.

Development of Impact Analysis and Discount Procedures

Two primary concerns of Navy personnel management are development of (1) gender-free strength tests (the same tests and criterion performance standard for both sexes), and (2) a capability for management to be aware of the effect of various selection cut-scores on men and women (hereafter termed the impact analysis procedure). The first concern was addressed by administering the same tests to similar numbers of men and women throughout all project phases to develop the STB (Robertson & Trent, 1982) and by applying common performance standards. The second concern required the development and demonstration of the following procedures for an impact analysis: (1) administer both the selector (STB) and criterion tests, (2) apply a quantifiable performance standard for the criterion tests, (3) determine a comparable cut-score on the selector (STB) that separates the same percentages of personnel who can and can not perform to the criterion standards, (4) calculate the percentages of personnel who would be excluded from entering a particular occupation, given a particular STB cut-score, and (5) adjust those percentages for changes in strength from physical conditioning experiences (hereafter termed discount procedure).

These procedures were demonstrated using two models, the "rectangular" and "regression" models. The rectangular model, termed by Flanagan (1951) as the "equi-percentile method," is the simpler one. Given the percentage of scores below the standard on the criterion test, an equal proportion of scores is cut off on the selector test. This method has the advantage of requiring no assumption about the shape of the distribution of scores, but it has the disadvantage of assuming a perfect correlation (r = 1.0) between the tests. The more complex regression model has the advantage of determining the actual relationship between two tests, but the disadvantage of assuming both a normal distribution and a straight-line relationship (using the linear regression method).

To anticipate gains in strength, the discount procedure employed an adjustment of the STB cut-score for a Navy entry population by a percentage similar to the estimated improvement from the physical conditioning program. For example, given an STB cut-score of 200 and an anticipated 10 percent gain in strength, the cut-score may be "discounted" downward to about 182, so that the 10 percent increase in strength would achieve an STB score of 200.

Because the discount procedure uses base-rate data from Navy entry personnel before and after they have completed recruit training, it was necessary to compare changes in STB means, particularly for armpull, armlift, and body weight, both for different entry years (1978 and 1983 were used) and for the start and end of recruit training. The impact analysis procedure was demonstrated by application of both the rectangular and regression models on the occupation-specific criteria, using a carry task (variable 12) and two different pull tasks (variables 25 and 28).

However, because of the relatively small sample sizes available for shipboard tests, only the simpler, rectangular model was tried out initially on the shipboard criteria. The discount procedure was demonstrated using the performance standards displayed in Table C-2 and an STB unit-weighted composite of armpull plus armlift (PL + LF). Table C-6 provides a comparison of the SIMA performance sample with a recruit (Navy entry) sample. As shown, positive effects result from recruits' physical conditioning program: When the discount procedure is applied, the percentages of recruits who are below the cut score are much smaller, especially for women, at the end of training, than at the beginning (see also Robertson, 1982). For example, the very rigorous test of carrying a stretcher up and down a ladder would eliminate none of the men and 88 percent of the women (see table C-6). If the positive effect of physical conditioning were not considered, the impact would be to eliminate a larger percentage of women--94 percent--as they entered recruit training. Likewise, the percentage of women who would be below the cut score on the test of moving through an 8-dog watertight door under operational or emergency conditions would be reduced from 46 to 23 percent using the discount procedure. (Note that actual STB (PL + LF) scores for an entry population of recruits at start and end of training were applied in Table C-6, rather than just an estimate of percentage strength gain.)

RESULTS

Distribution Statistics and Correlates for Men and Women With STB and Occupation Specific Tasks

Appendix E presents STB and criterion test (variables 1-27) means and inter-correlations; Table 5 presents means and standard deviations for the STB and criterion

Table 5

STB and Criterion Task Performance Scores

Test	Abbrev.	Sex	N	Mean	SD	$\frac{W}{M}\times 100$	Percentage[a] Overlap
STB							
1. Armpull	ARMPL	M W	274 258	150.51 88.64	24.48 16.72	58.89	14
2. Armlift	ARMLF	M W	274 258	107.37 63.51	17.66 12.09	59.04	14
3. Ergometer	ERGOM	M W	274 256	66.56 30.34	9.50 12.00	45.72	9
4. Height	HT	M W	274 260	69.56 64.69	2.69 2.46	93.00	34
5. Weight	WT	M W	274 259	162.42 132.20	22.71 16.44	81.59	44
6. Sit-up	SITUP	M W	273 259	39.32 30.26	6.05 6.10	76.96	46
7. ILM-jerk	LMJRK	M W	274 240	108.72 58.67	21.62 11.01	53.96	13
8. ILM-press	LMPRS	M W	273 239	103.85 53.35	18.52 9.42	51.37	7
9. ILM-elbow	LMELB	M W	274 237	85.77 47.68	17.28 7.98	55.59	15
CRITERION TASK (and applicable category or job)							
<u>Carry type</u>							
10. Drop-tank carry (AD)	DRPTK	M W	213 189	6.34 2.74	1.24 2.02	37.83	27
11. Tow-bar run (clear) (ABH)	TWB-C	M W	229 214	12.21 4.47	2.30 1.94	36.69	7
12. Tow-bar run (across cable) (ABH)	TWB-X	M W	230 214	9.19 3.01	2.14 2.05	32.75	14
13. Fuel probe/acetylene bottle carry (BM, HT)	FP/AC	M W	209 192	11329.65 8017.50	1322.33 2060.32	70.77	33
14. Crucible pour (ML)	CRUCB	M W	215 73	164367.81 115146.69	10694.48 30062.63	70.05	90
15. 5-gallon can carry (BM, ship)	5GCAN	M W	216 184	5463.53 3880.69	1544.34 788.86	71.03	50
16. Equipment carry (ladder) (avia,ship)	EQUIP	M W	211 171	7525.65 5870.64	1643.73 2712.63	78.01	70
17. Acetylene bottle carry (ladder) (HT)	ACETB	M W	215 77	13316.34 7160.71	1397.30 4997.61	53.77	34
<u>Lift Type</u>							
18. MK82 bomb load (AO)	BOMBL	M W	244 208	132.70 66.20	25.73 15.12	49.88	10
19. Canopy raise (1-arm) (AME)	CNPY1	M W	260 194	57.18 30.59	11.66 7.24	53.50	16
20. Canopy raise (2-arm) (AME)	CNPY2	M W	259 194	87.34 46.46	9.08 23.01	53.19	26
<u>Pull or push type</u>							
21. Rope pull (initiating 160 pounds) (BM)	RP160	M W	185 141	1.00 0.12	0.64 0.18	12.00	29
22. Rope pull (sustaining 60 pounds) (BM)	RP60	M W	193 199	6.46 3.21	2.09 1.00	49.69	29
23. Cart pull (initiating 75 pounds) (AS)	CRT75	M W	219 178	6.20 2.26	1.50 0.89	36.45	10
24. Cart pull (sustaining 45 pounds) (AS)	CRT45	M W	241 154	10.04 5.36	1.63 1.80	53.39	39
25. Fuel hose drag (105 pounds) (ABF)	HS105	M W	212 178	4.28 0.65	1.70 0.52	15.19	10
26. Power cable rig (80/100 pounds) (EM)	CR100	M W	248 179	2.62 0.34	1.20 0.54	12.98	19
27. Bolt torque (ABE)	BLTRQ	M W	233 163	145.16 88.34	26.37 17.53	60.86	20

[a]Tilton (1937) index of overlap.

tests, as well as for the two indices that compare men's and women's averages (the ratio of means and percentage overlap). Again, the means of the two gender subgroups were disparate, and the static measures (variables 1 and 2) appear to be consistent with the conclusions of Laubach (1976)--women's means about 60 percent of men's means (see also Robertson, 1982, pp. 8 and 12). In Table 5, the ratio of women's to men's means is 59 percent (variables 1 and 2). But the Tilton (1937) index of overlap indicates that the distributions are widely separated--only 14 percent overlap on each. The Tilton overlaps varied from 7-46 percent on the STB measures, and from 7-90 percent on the criterion tests.

Correlations were calculated (see Table 6) between each of 18 criterion variables (V10-V27) and some STB single and unit-weighted variables (V1-3, 5, 7-9, 28-34). Then to provide an overview (see Table 7), average correlations for the 18 criterion variables were calculated for each of those STB variables (except those with more than two singles in the composite, V30 and 34). As shown in Table 7, the best single component appears to be the armpull (ARMPL, r = .452), followed closely by the (ERGOM, r = .439) and the ILM press (LMPRS, r = .409). For the unit-weighted composites of armpull plus another component of the STB, the results were very similar--adding ergometer (PL + RG) yielded an average r = .490, ILM jerk or press (PL + JR or PR) r = .485 or .488, and armlift (PL + LF) r = .476. (However, the ergometer and ILM have other logistic difficulties for their potential implementation as testing devices in applicant processing centers, and these difficulties will be addressed in the utility analysis section of the next report.)

As shown in Table 6, of the three alternative procedures by which the USAF-developed ILM was administered, jerk (V7), press (V8), and elbow (V9) respectively, the press mode was superior. The press mode correlations were superior 28 times (16 for men and 12 for women) to the jerk mode (2 for men and 2 for women). Perhaps the jerk mode is confounded by the "continuous" lift procedure (i.e., confounding the lower torso strength capability with that of the upper torso). For example, on the criterion performance of tow-bar run (V11), the men's correlations for components V7 and V8 increase from .36 to .41, but the women's remain the same, .21. On criterion performance of fuel hose drag (V25), men's correlations increase from .24 to .35, but women's increase only .43 to .44.

Combining two STB components (e.g., armpull and armlift, etc., see variables 28-34, Table 6) into a composite, tended to increase correlation values a few points. For example, on the criterion task of drop tank carry (V10), the separate correlations for men on armpull (.39) and armlift (.36) increase to .43 (V28) when a unit-weighted composite was formed, and women's separate correlations of .41 and .32 increase to .42. A few correlations remain the same, and a few others increased substantially. Most STB components (i.e., individual variables) showed strong relationships with criterion performance on all tasks--generally correlations in the .30s-.60s for separate gender subgroups.

Correlations for the Total Sample

Combining the men and women into a total sample increased the correlations substantially, typically 30 to 50 correlation points (see Table 8), especially where corelations for the separate subgroups had been low. For example, on the test of tow-bar run (V11), men's and women's correlations with body weight (V5) increased from .26 and .18 separately (Table 6) to .63 for the combined group (Table 8). The higher correlations for the total group result primarily from an artificially spread variance (i.e., most women's scores fall at the bottom of the distribution and most men's scores at the top)

Table 6

Validity Coefficients of STB, Single and Unit-Weighted Measures, For Criterion Tasks

Criterion Task	Abbrev. (and rating)	Sex	N	Single (1) ARMPL	(2) ARMLF	(3) ERGOM	(5) WT	(7) LMJRK	(8) LMPRS	(9) LMELB	(28) PL+LF	(29) PL+WT	Composite (30) P+L+W	(31) PL+RG	(32) PL+JR	(33) PL+PR	(34) PLWRE
Carry																	
10 Drop-Tank Carry	DRPTK	M	213	39	36	40	26	27	29	23	43	39	42	43	38	40	43
	(AD)	W	189	41	32	48	24	45	45	38	42	38	40	49	30	48	49
11 Tow-Bar Run (Clear)	TWB-C	M	229	43	34	31	26	36	41	27	45	41	43	49	46	48	48
	(ABH)	W	214	36	26	32	18	21	21	13	36	32	33	38	33	34	35
12 Tow-Bar Run (across cable)	TWB-X	M	230	33	31	38	26	24	28	22	36	35	37	37	33	35	39
	(ABH)	W	214	27	25	27	19	26	27	17	30	28	30	31	31	31	33
11/12 Tow-Bar Run (total)	TWBCX	M	229	45	38	33	30	35	41	29	48	44	47	51	47	49	51
	(ABH)	W	214	34	28	32	20	26	26	17	36	33	35	38	36	35	38
13 Fuel Probe/Acetylene Bottle Carry	FP/AC	M	209	37	29	37	26	44	41	41	38	37	38	40	46	44	42
	(BM)	W	192	38	31	43	34	35	37	36	40	43	44	46	41	42	48
14 Crucible Pour	CRUCB	M	213	36	24	31	27	41	39	41	35	37	36	37	44	42	40
	(ML)	W	73	55	48	45	55	49	49	40	58	63	64	58	62	61	67
15 5-Gallon Can Carry	5GCAN	M	216	49	37	41	42	37	39	35	49	51	51	50	49	49	52
	(BM,Ship)	W	184	37	35	45	38	51	52	42	41	45	46	46	50	49	54
16 Equipment Carry (ladder)	EQUIP	M	211	53	46	48	39	32	37	32	56	53	56	56	50	52	56
	(Ava/Shp)	W	171	50	30	41	38	44	47	44	48	53	51	53	55	56	55
17 Acetylene Bottle Carry (ladder)	ACETB	M	215	60	54	64	61	45	53	46	64	69	70	66	60	64	72
	(HT)	W	77	60	44	50	55	57	60	51	59	57	57	62	71	71	65
Lift																	
18 MK82Bomb Load	BOMBL	M	264	55	59	57	62	53	60	53	64	68	71	61	63	65	74
	(AO)	W	208	37	28	42	34	33	37	36	37	42	42	45	37	39	46
19 Canopy Raise (1-arm)	CNPY1	M	260	48	40	50	38	52	52	48	50	50	51	52	57	56	56
	(AME)	W	194	25	15	35	21	23	28	28	23	27	26	33	29	31	33
20. Canopy Raise (2-arm)	CNPY2	M	259	46	35	44	42	42	44	45	46	51	51	49	51	51	53
	(AME)	W	194	33	21	36	28	24	29	39	31	36	35	39	34	36	39
Pull or Push																	
21 Rope Pull (initiating 160 pounds)	RP160	M	185	43	33	42	46	16	26	22	44	52	51	46	35	40	48
	(BM)	W	141	42	39	34	42	42	44	39	48	53	53	47	54	54	56
22 Rope Pull (sustaining 60 pounds)	RP60	M	193	25	20	27	20	01	08	05	24	25	26	26	15	19	24
	(BM)	W	199	48	41	43	46	46	45	46	50	55	57	51	53	50	57
23 Cart Pull (initiating 75 pounds)	CRT75	M	219	41	33	48	38	55	57	46	42	46	46	46	54	54	54
	(AS)	W	178	60	55	49	47	56	55	46	64	63	66	61	67	65	68
24 Cart Pull (sustaining 45 pounds)	CRT45	M	241	45	36	58	44	36	43	23	47	52	52	52	48	50	56
	(AS)	W	154	47	47	44	48	40	42	43	53	57	60	50	52	51	61
25 Fuel Hose Drug (105 pounds)	HS105	M	212	45	41	57	49	24	35	20	49	54	55	52	41	46	56
	(ABF)	W	178	49	38	35	41	43	44	33	50	52	53	49	56	55	56
26 Power Cable Rig (80/100 pounds)	CB100	M	248	54	52	57	58	44	48	37	60	65	67	59	57	58	69
	(EM)	W	179	39	30	37	29	38	39	43	39	40	40	42	46	45	46
27 Bolt Torque	BLTRQ	M	233	78	54	55	48	34	42	33	77	73	74	77	66	71	71
	(ABE)	W	163	68	46	49	38	46	51	52	63	62	62	67	70	72	67

Note. Decimal points of correlations have been omitted. Sample were recruits in latter half of 7-weeks training, N = 274 men, 239 women. Correlation ns varied 185-260 men, 141-214 women (except V14 = 77, V17 = 73). For n = 200, r = .14-.17 significant at .05 level, .18+ at .01. For n = 150, r = .16-.20 at .05, .21+ at .01. For n = 75, r = .22-27 at .05, .28+ at .01.

Table 7

Average STB Correlation Coefficients
For 18 Criterion Tasks

STB Variable	Average of STB Correlation Coefficients--Criterion Variables 10-27: Men	Women	Total
Single			
1. ARMPL	.46	.44	.452
2. ARMLF	.39	.35	.368
3. ERGOM	.47	.41	.439
5. WT	.40	.35	.376
7. LMJRK	.36	.40	.380
LMPRS	.40	.42	.409
LMELB	.33	.38	.357
Unit-weighted composite			
28. PL+LF	.50	.45	.476
29. PL+WT	.50	.47	.484
31. PL+RG	.50	.48	.490
32. PL+JR	.47	.50	.485
33. PL+PR	.48	.49	.488

Table 8

STB Validity Coefficients, Single and Unit-Weighted Measures, for Occupational-Specific Criterion Tasks, Combined Men's and Women's Samples

	Criterion Task	Abbrev. (and rating)	N	Single							Composite						
				1 ARMPL	2 ARMLF	3 ERGOM	5 WT	7 LMJRK	8 LMPRS	9 LMELB	28 PL+LF	29 PL+WT	30 P+L+W	31 PL+RG	32 PL+JR	33 PL+PR	34 PLWRE
CARRY																	
10	Drop-Tank Carry	DRPTK (AD)	402	74	73	79	58	72	74	69	76	73	75	78	77	77	79
11	Tow-Bar Run (clear)	TWB-C (ABH)	443	83	81	86	63	81	84	78	86	81	84	87	86	86	87
12	Tow-Bar Run (across cable)	TWB-X (ABH)	444	78	78	81	62	76	79	74	81	77	80	81	80	81	82
11/12	Tow-Bar Run (total)	TWBCX (ABH)	443	84	82	86	65	81	85	79	86	82	85	87	86	87	88
13	Fuel Probe/ Acetylene Bottle Carry	FP/AC (BM)	401	77	75	80	63	78	79	77	79	77	79	80	80	81	81
14	Crucible Pour	CRUCB (ML)	286	70	64	71	57	72	73	70	71	70	71	73	75	74	74
15	5-Gallon Can Carry	5GCAN (BM,SHIP)	400	76	72	76	65	73	75	70	77	77	77	78	78	78	79
16	Equipment Carry (ladder)	EQUIP (AVIA,SHIP)	382	82	79	80	66	75	79	74	83	81	83	84	82	83	84
17	Acetylene Bottle Carry (ladder)	ACETB (HT)	292	82	79	82	72	75	80	74	84	84	86	85	83	85	87

Table 8 (Continued)

	Criterion Task	Abbrev. (and rating)	N	Single							Composite						
				1 ARMPL	2 ARMLF	3 ERGOM	5 WT	7 LMJRK	8 LMPRS	9 LMELB	28 PL+LF	29 PL+WT	30 P+L+W	31 PL+RG	32 PL+JR	33 PL+PR	34 PLWRE
LIFT																	
18	MK82 Bomb Load	(BOMBL) (AO)	452	85	85	85	75	83	87	83	88	87	89	88	88	89	91
19	Canopy Raise (1-arm)	CNPY1 (AME)	454	79	77	81	64	80	82	79	81	79	81	83	84	84	84
20	Canopy Raise (2-arm)	CNPY2 (AME)	453	82	79	85	66	80	83	80	84	81	83	86	85	85	86
PULL OR PUSH																	
21	Rope Pull (initiating 160#)	RP160 (BM)	326	72	68	69	66	60	66	62	73	75	75	73	69	71	74
22	Rope Pull (sustaining 60#)	RP60 (BM)	392	69	68	71	58	61	66	61	71	70	71	72	68	69	72
23	Cart Pull (initiating 75#)	CRT75 (AS)	397	83	81	85	69	85	88	81	85	83	85	86	87	88	88
24	Cart Pull (sustaining 45#)	CRT45 (AS)	395	80	78	85	70	77	81	73	83	82	84	84	83	84	86
25	Fuel Hose Drag (105#)	HS105 (ABE)	390	81	79	82	71	74	79	71	83	82	84	84	81	83	85
26	Power Cable Rig (80/100#)	CB100 (EM)	427	81	80	80	73	77	80	74	83	84	85	83	82	83	86
27	Bolt Torque	BLTRQ (ABE)	396	91	82	82	69	75	80	74	90	88	89	90	88	89	89

Note. Decimal points of correlations have been omitted. Sample were men and women recruits in latter half of 7-weeks training, $N = 533$. Correlation ns varied 286-454. For $n = 300$, all $r = .15+$ significant at .01.

and thus can be very misleading. Even near-zero or negative validities for the separate gender subgroups can be converted to large positive values by combining the samples.

Unit vs. Optimal Weighting of STB Components

Table 9 was prepared to provide a comparison between results of the more complex, optimal weighting procedure, multiple regression analysis, and the simpler, unit-weighted procedure (Table 6). Generally, using multiple regression analysis produced negligible improvement. In fact, unit-weighted values were usually a few correlation points higher than the resultant shrinkage in the cross-validation following the multiple regression analyses. For example, on the criterion of a lifting task (V18), the men's unit-weighted correlation of .64 (V28) increases to .65 (V35) on multiple regression analysis and back to .64 on cross-validation; the women's correlation increases from .37 to .42, but then shrinks to .27. (Of course, no standard procedure exists to apply a shrinkage formula, comparable to cross-validation of regression analysis, to unit-weighted analysis. However, in the present analysis, the unit-weights were determined a priori based on results of testing other samples.)

Impact Analysis

Applying the performance standards in Table B-1 to STB distributions of components such as the unit-weighted composite of armpull-plus-armlift (see PL + LF column, Table 10), excluded most or all women but few men (see the two "No Discount" columns of Table 10). There were, however, some exceptions. For example, on the criterion task of initiating a cart pull (V23), only 21 percent of women would be excluded, applying entry data. When very few subjects are excluded by a selection test, that is, when the selection ratio is near 100 percent, the test is not beneficial for the organization because none of the poor performers are excluded. Thus, the present results do not provide useful differentiation among men, but they provide substantial differentiation among women.

Gains in Weight and Strength

The data in Table 11 not only permit comparisons of recruits over a 5-year period, but also provide support for the discount procedure applied in Table 10 (Robertson, 1982). As shown in Table 11, between 1978 and 1983, the recruits that entered the Navy increased in weight. Comparing the body weight for male recruits shows an increase of about 5 pounds, from 157.3 to 162.4 ($p < .01$), and for female recruits about 3 pounds, from 129.6 to 132.2 ($p < .02$). Armpull, the best single predictor of Navy criterion tasks, shows the benefits gained from physical conditioning. Comparing two columns of Table 11, the 1978 longitudinal sample, weeks 1-1 and 7-3, shows men's strength increasing from the start to the end of training, 148.7 to 156.5 pounds ($p < .001$ for correlated means); for women, the strength increases from 80.2 to 92.5 pounds ($p < .001$).

The discount procedure takes into account the benefits of physical conditioning, thus reducing substantially the percentage of recruits that would have been excluded by straightforward application of strength performance standards. As shown in Table 10, for example, the percentages of women excluded on V23 are reduced from 21 to 9 or 5 percent (by the 10% or 15% discount procedure respectively); and for V10, from 52 percent to 25 or 17 percent. (The 10% and 15% discount procedures are presented in Table 10 for demonstration; they have not yet been validated longitudinally on work samples.) The percentages of recruits excluded by the impact analysis on occupation-specific tasks are similar to the percentages excluded on shipboard tasks (Table C-6).

Table 9

Comparison of Unit-Weighted and Multiple Regression Correlation Coefficients for Three Criterion Tasks--Carry, Lift, and Pull

				STB										
				Unit-Weighted[b]			Optimal-Weighted Multiple Regression (R) and Cross-Validation (X-Val)[a,c]							
				28	29	31	35		36		37		38	
Type of Criterion Task (and Rating)	Abbrev.	Sex	N	PL+LF	PL+WT	PL+RG	R	PL+LF X-Val	R	PL+WT X-Val	R	PL+RG X-Val	R	PLWRE X-Val
Carry														
13 Fuel probe/acetylene bottle carry (BM, HT)	FP/AC	M	209	38	37	40	38	38	39	37	44	33	46	42
		W	174	40	43	46	46	29	45	39	46	45	47	49
Lift														
18 MK82 bomb load (AO)	BOMBL	M	241	64	68	61	65	64	67	70	61	65	76	73
		W	186	37	42	45	42	27	45	35	46	45	51	43
Pull														
25 Fuel hose drag (ABF)	HS105	M	212	49	54	52	48	50	53	57	56	63	61	61
		W	162	50	52	49	52	45	53	50	50	47	60	53

Note. Decimal points of correlations have been omitted.

[a]Multiple regression analysis performed on a random 2/3s sample and cross-validated on the other 1/3.

[b]For all unit-weighted validities, $p < .001$.

[c]For all cross-validities, $p < .001$ except: Vs18 and 35 $r = .27$, $p < .05$; Vs 18 and 36 $r = .35$, $p < .01$; Vs 13 and 37 $r = .33$, $p < .01$.

Table 10

Demonstration of Impact Analysis for Occupation-Specific Tasks

				TP Std.[a]			TPT Sample[b]		Entry Sample[c]					
									No Discount		10% Discount		15% Discount	
	Task	Rating	Abbrev.	Weight or Force (pounds)	WKO	Sex	% Below TP Std.	STB Cut-Score[d] PL+LF	STB PL+LF	% Excluded	STB PL+LF	% Excluded	STB PL+LF	% Excluded
10	Drop-tank carry	AD	DRPTK	100	1.33	M	0.0	99.04	99.04	0	89.17	0	84.18	0
						W	31.7	139.39	139.39	52	125.63	25	118.63	17
11	Tow-bar run (clear)	ABH	TWB-C	62	5.45	M	0.0	158.11	158.11	0	142.30	0	134.39	0
						W	72.9	166.50	166.50	85	149.85	70	141.53	57
12	Tow-bar run (across cable)	ABH	TWB-X	62	4.62	M	3.5	198.17	198.17	8	178.35	2	168.44	1
						W	79.0	171.12	171.12	91	154.01	74	145.45	62
11/12	Tow-bar run (total)	ABH	TWBCX	62	10.07	M	0.7	170.00	170.00	1	153.00	0	144.50	0
						W	62.2	159.13	159.13	80	143.22	59	135.26	45
13	Fuel probe/acetylene bottle carry	BM	FP/AC	120	2.67	M	28.7	236.46	236.46	34	212.81	94	173.88	8
						W	97.6	204.56	204.56	99	181.04	94	173.88	91
13	Fuel probe/acetylene bottle carry	HT	FP/AC	114	2.53	M	18.2	222.91	222.91	20	100.62	8	189.47	3
						W	83.9	174.63	174.63	92	157.17	78	148.44	60
14	Crucible pour	ML	CRUCB	153	87.43	M	8.0	206.43	206.43	10	185.79	3	175.47	1
						W	90.4	182.53	182.53	94	164.03	84	155.15	74
15	5-gallon can carry	BM, Ship	5GCAN	60	.33	M	67.7	254.84	254.84	54	229.36	28	216.61	16
						W	98.4	210.00	210.00	99	189.00	97	178.50	93
16	Equipment carry (ladder)	Avia., Ship	EQUIP	70	.74	M	5.7	202.67	202.67	9	182.40	2	172.27	1
						W	74.9	168.77	168.77	88	151.89	71	143.45	59
17	Acetylene bottle carry	HT	ACETB	133	5.32	M	18.6	223.00	223.00	20	200.70	8	189.5	3
						W	100.0	265.60	265.60	100	239.04	100	225.76	100
18	MK82 bomb load	AO	BOMBL	140	--	M	49.6	256.25	256.25	56	230.63	29	217.81	17
						W	100.0	277.58	277.58	100	249.82	100	235.95	100
19	Canopy raise (1-arm)	AME	CNPY1	54	--	M	10.0	213.75	213.75	14	192.38	4	181.69	2
						W	95.9	199.63	199.63	99	179.67	94	169.69	89
20	Canopy raise (2-arm)	AME	CNPY2	65	--	M	0.0	197.64	197.64	7	177.88	2	167.99	1
						W	92.8	185.88	185.88	96	167.29	87	158.00	79
21	Rope pull (initiating 160 pounds)	BM	RP160	160	.17	M	3.2	195.88	195.88	6	176.29	1	166.50	1
						W	74.5	168.56	168.56	88	151.70	71	143.28	59
22	Rope pull (sustaining 60 pounds)	BM	RP60	60	.67	M	0.0	47.59	47.99	0	42.83	0	40.45	0
						W	0.0	47.59	47.99	0	42.83	0	40.45	0
23	Cart pull (initiating 75 pounds)	AS	CRT75	75	1.20	M	0.0	110.90	110.90	0	99.81	0	94.27	0
						W	10.7	122.88	122.88	21	110.59	9	104.45	5
24	Cart pull (sustaining 45 pounds)	AS	CRT45	45	1.25	M	0.0	36.68	36.68	0	33.01	0	31.18	0
						W	0.6	71.75	71.75	1	64.58	0	60.99	0
25	Fuel hose drag (105 pounds)	ABF	HS105	105	1.00	M	0.5	164.00	164.00	1	147.60	0	139.40	0
						W	77.0	170.44	170.44	90	153.40	71	144.87	62
26	Power cable rig (80/100 pounds)	EM	CB100	100	.53	M	3.6	198.50	198.50	8	178.65	2	168.73	1
						W	81.0	172.50	172.50	91	155.25	74	146.63	65
27	Bolt torque	ABE	BLTRQ	90	--	M	0.9	173.88	173.88	1	156.49	0	147.80	0
						W	57.7	156.36	156.36	77	140.72	35	132.91	39

[a]TP Std—Task performance standard.

[b]TPT—Task performance test; sample were recruits in latter half of training (see Table 5 for Ns).

[c]Entry sample were recruits tested on first day of training (data from Robertson, 1982).

[d]STB cut-score based on same percentage as that cut-off by percentage below TP Std (i.e., application of rectangular method). If the percentage was outside the range of the gender subgroup scores (i.e., outside 0-100%), the STB cut-score was determined by the regression method.

Table 11

Average STB Scores for Entry Personnel and Other Navy Organizations

Test	Abbrev.	Sex	Mean Score by Organization: Orlando Recruits 1978, Total Sample Wk. 1-1	Orlando Recruits 1978, Longitudinal Sample[b] Wk. 1-1	Orlando Recruits 1978, Longitudinal Sample[b] Wk. 7-3	Orlando Recruits 1978, Total Sample Wk. 7-3	Orlando Recruits 1983, Wk. 4-7[c]	1983 SIMA	1978 UDT
4 Height (inches)	HT	M	68.8	--	--	68.9	69.6	68.2	69.0
		W	64.4	--	--	63.9	64.7	64.2	--
5 Weight (pounds)	WT	M	157.8	157.1	156.2	157.3[c]	162.4[c]	164.6	164.6
		W	128.0	128.5	129.6	129.6[c]	132.2[c]	136.7	--
Percent Fat	PCFAT	M	13.9	13.9	12.6	12.5	--	17.9	11.4
		W	24.6	24.8	24.5	24.6	--	27.9	--
Push-up	PSHUP	M	18.7	19.2	25.8	25.5	--	27.4	50.5
		W	1.9	2.2	6.1	5.8	--	7.1	--
6 Sit-up[a]	SITUP	M	18.0	18.2	20.6	30.4	39.3	28.9	55.7
		W	13.6	13.9	16.9	18.6	30.3	27.5	--
1 Arm pull (pounds)	ARMPL	M	147.5	148.7	156.5	156.9	150.5	127.1	160.1
		W	79.4	80.2	92.5	92.8	88.6	92.3	--
2 Arm lift (pounds)	ARMLF	M	104.8	106.0	99.6	98.9	107.6	101.5	118.4
		W	60.9	61.7	61.5	61.0	63.5	68.2	--
3 Ergometer[b] (revolutions)	ERGOM	M	58.4	58.4	69.3	68.4	66.4	52.0	106.1
		W	35.0	35.6	41.0	39.7	30.3	34.9	--
N		M	350	266		493	274	36	69
		W	269	195		243	258	31	--

Note. Recruit training (week-day): Wk 1-1--first day, wk 7-3--last day, wk 4/7--latter half, within 4th-7th wk. Longitudinal sample--subsample of subjects for whom both a 1st and last day score was available. SIMA--shore intermediate maintenance activity. UDT--underwater demolition team (Robertson & Trent, 1983).

[a]Administration time varied: seconds were 30 for 1978 recruits and SIMA, 60 for 1983 recruits, and 120 for UDT.

[b]Administration time varied: Seconds were 30 for all groups, except 60 for UDT.

[c]For mean differences: 157.3-162.4 (men), t = 3.196 $p<.01$; 129.6-132.2 (women) t = 2.434 $p<.02$.

DISCUSSION

Separate Cut-Scores for Men and Women

For both shipboard and occupation-specific criterion tests, combining the two subgroups (see Tables C-5 and 8), yielded validity coefficients substantially greater than those of the separate groups. There is thus the temptation to select and use the greatest validity coefficient from the total group. Furthermore, analysis on one group is simpler than additional analyses on subgroups. Implicit in the temptation to use one total group are the assumptions, however, that (1) the members of any subgroup are randomly and evenly distributed throughout the total group, and that (2) cut-scores from the total group would not bias the member of a subgroup. Both assumptions are quite tenuous in the case of strength tests.

Tests of selection fairness have been extensively designed, discussed, and critiqued in the technical literature. The multiple regression analysis approach of Bartlett et al. (1978) proposes a three-step strategy for differential prediction and distinguishes this procedure from the concepts of single-group validity and differential validity. Essentially, the three steps are to (1) compute the validity coefficient for the total group, (2) check for differences in the intercepts of the subgroups, and then (3) check for interaction between the subgroups and the total group ability. Unfairness is established if there is a difference in slopes, intercepts, or both; Barlett et al. suggest checking intercepts before slopes. Gulliksen and Wilks (1950) suggest checking for a difference in slopes before intercepts, but the result would be the same--unfairness is established if a difference exists in either.

Because of the importance of the issue of fairness, the possible differences between gender groups were investigated by multiple regression analysis and also by the rectangular method. Van Naerssen (1965) observed that actual test scores are never distributed normally and that the actual distribution usually falls between a normal model (on which multiple regression analysis is based) and a rectangular model; for payoff distribution, it is probably safest to assume a rectangular distribution. (Payoff considerations will be addressed in a follow-on report.) The rectangular procedure applied in the present analysis took similar proportions on both the selector and criterion variables below the performance standards, regardless of the shape of either variable's distribution, adjusted for a Navy entry population. Analyses using the rectangular and regression models are illustrated in Figures 2 through 4, and F-1 through F-3 (regression model only), applying some of the task performance standards displayed in Table B-1.

The scatterplots display the distribution of scores for a carry task (Figure F-1, V12) and two pull tasks (Figures F-2, V25, and F-3, V26). The scatterplots also show the linear regression lines both for the total group, as well as the separate gender subgroups, and also the performance standard (dashed horizontal line) from Table B-1. Figures 2, 3, and 4 show an expanded part of the same distributions in the vicinity of the performance standard, and demonstrate the results of STB (armpull plus armlift composite) cut-off scores by regression and rectangular methods. It may be observed from Figures F-1, F-2, and F-3 that the regression lines for the total group typically cut through the middle of each gender subgroup, and are steeper than the separate gender lines (probably because of the greater obtained correlation coefficient--see Table 8--for the total group). It may also be observed from an inspection of the scatterplots that the actual distributions may not be very normal or linear.

In Figure 2, the regression lines (men's $y = 3.626 + .022x$; women's $y = -.901 + .026x$) are nearly parallel but widely separated (by intercept). Applying the performance

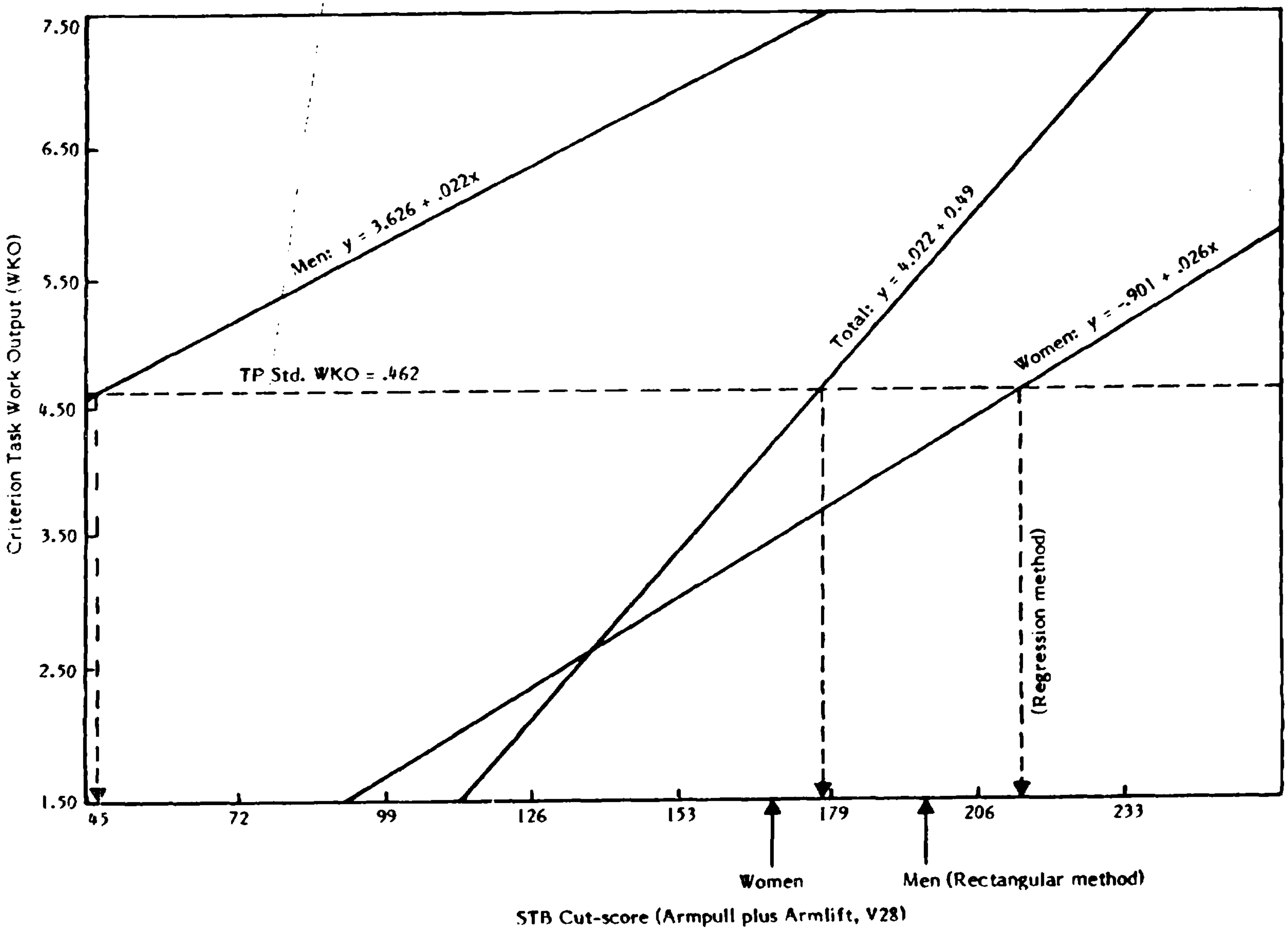


Figure 2. Comparison of STB cut-scores by rectangular and regression methods for a carry task--tow-bar run across cable (variable 12, see Table B-1 for WKO formula.

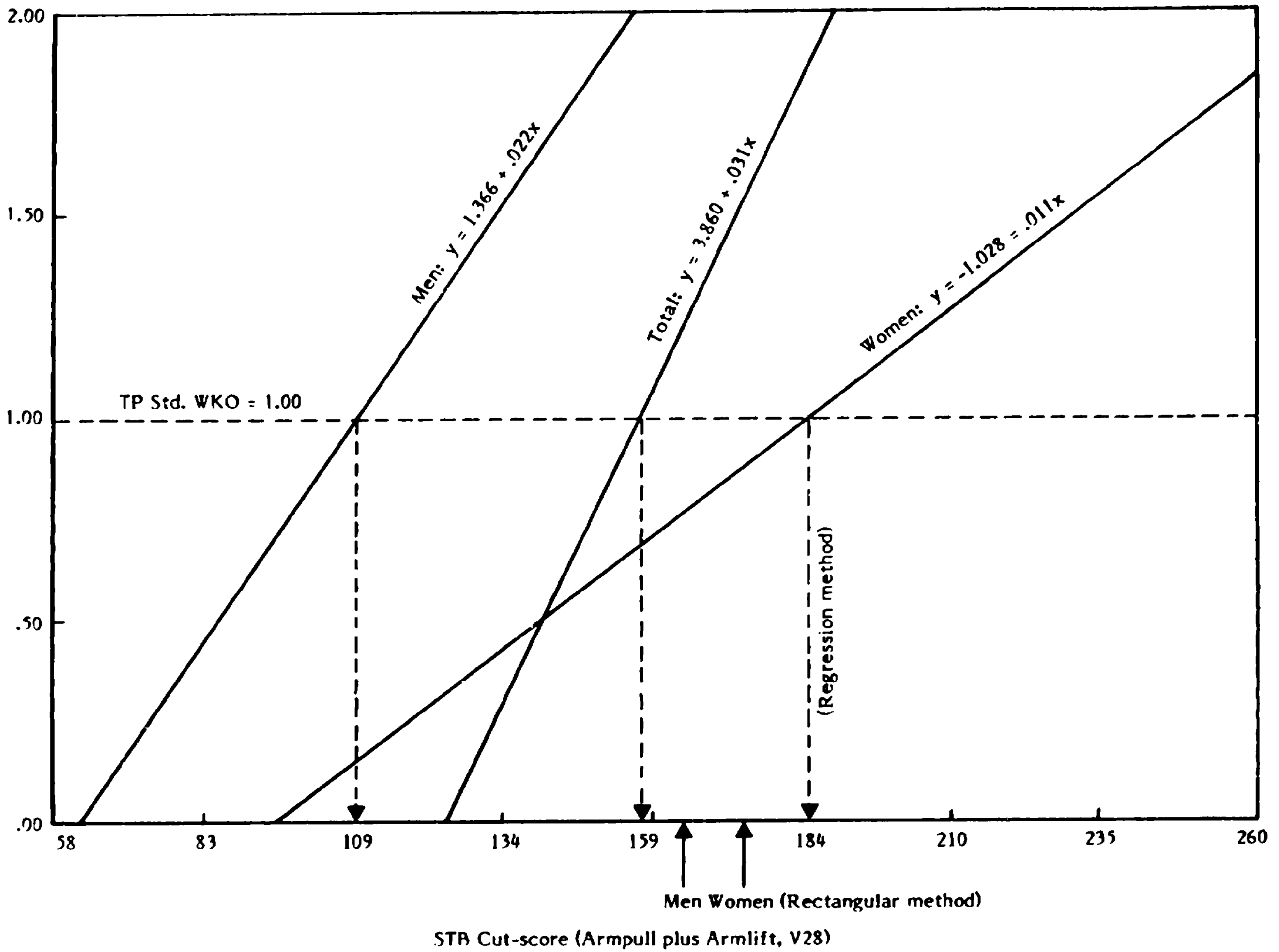


Figure 3. Comparison of STB cut-scores by rectangular and regression methods for a pull task—fuel hose drag (variable 25, see Table B-1 for WKO formula).

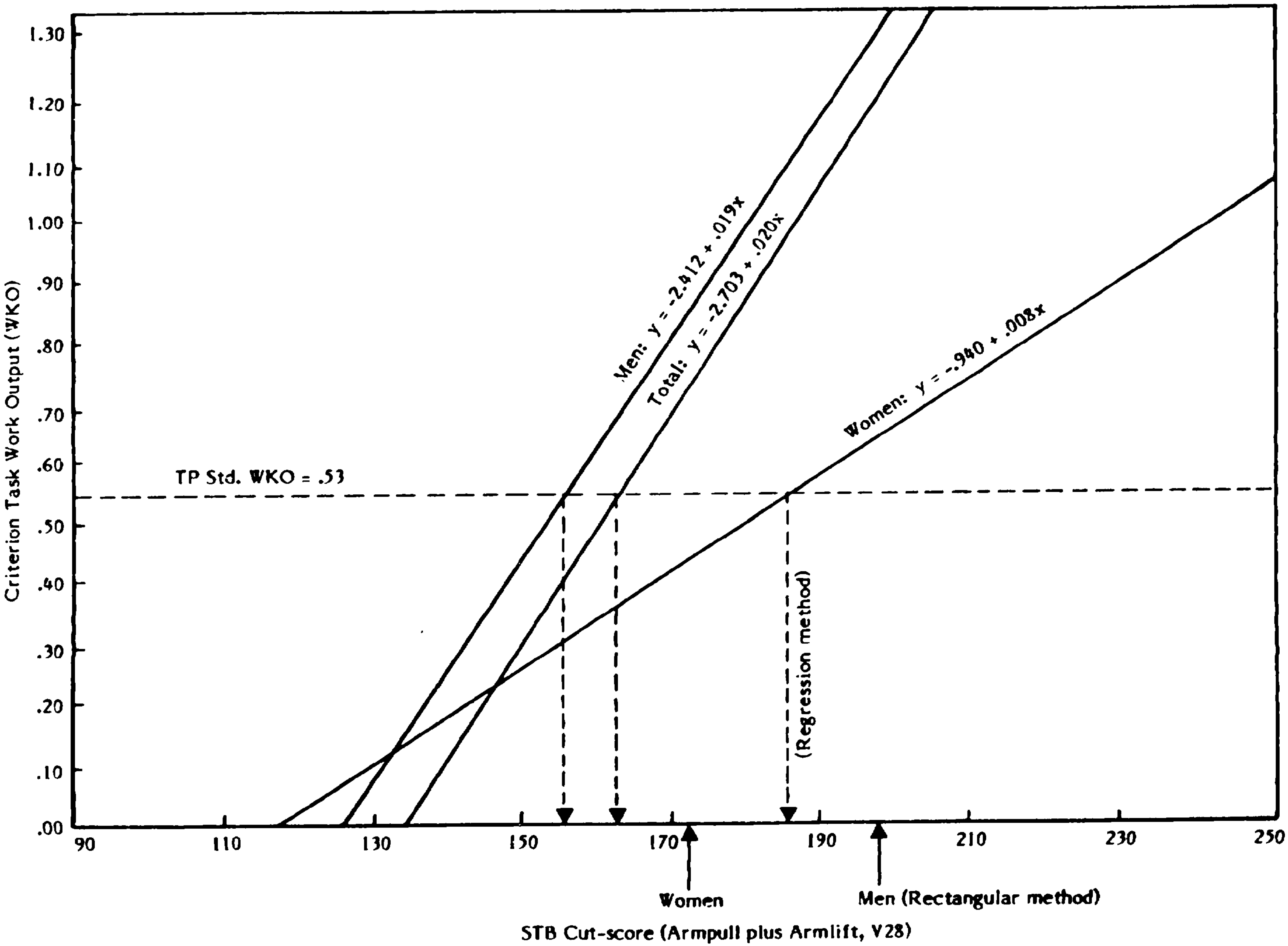


Figure 4. Comparison of STB cut-scores by rectangular and regression methods for a pull task--power cable rig (variable 26, see Table B-1 for WKO formula).

standard (WKO = 4.62) to the men's regression line yields a cut-score (V28--following the solid line up) of men's 198 and women's 171. Figures 3 and 4 present similar formats, but vary in the relationship of the regression line slope for the total group to those of the subgroups.

In all criterion performance standards, substantial differences exist between men's and women's intercepts, especially at the standard of performance. The ratios of STB cut-scores also vary considerably between men and women, applying the same performance standard. Consider the tasks in Figures 3 and 4, both pulling tasks, by the regression method. The men's STB requirement in Figure 3 (following the dashed line down) is about 108; the women's is 185, or about 1.7 times the men's requirement, but in Figure 4, it is only about 1.2 times the men's requirement. In Figure 2, the women's requirement is nearly 5 times the men's. Considering the wide variance in the variables that determine WKO--force, distance, time--these results strongly suggest the importance of specific criterion tasks for specific jobs, rather than use of a generic lift, carry, or pull task to represent many jobs.

Women's STB cut-scores are much higher than men's by the regression method, but vary by the rectangular method (e.g., in Figures 2 and 4, the women's cut-scores are slightly lower than men's). The regression lines of the total group yield cut-scores fairly close to those of women by the rectangular method. The use of the regression line of the total group would be biased against men, (that is, the total group's cut-score would be much higher than the men's cut-score, using the men's regression line). The rectangular method yields better (lower) STB cut-scores for women than the regression method, perhaps in part because of the assumption of a perfect correlation by the rectangular method. Any time the correlation is less than perfect, there will of course be some errors in selection.

The three-step strategy proposed by Bartlett et al. (1978) is demonstrated in Table 12, which displays the three criterion tasks used to illustrate Figures 2 through 4 (variables 12, 25, and 26 respectively). Each step 1 simply displays the validity coefficient for the total group similar to Table 8 (variable 28). In each step 2, the gender effect on the intercepts, the differences are highly, statistically significant--beyond the .01 level. Although the interaction effects vary in step 3, they are irrelevant because unfairness (if the total group were used) has been strongly detected in step 2. Thus, the use of separate procedures for men and women, regardless of the method used, regression or rectangular, appears to be necessary.

Relationship Among Dynamic Strength, Static Strength, and Body Weight

It is common knowledge that heavy people have greater difficulty moving their bodies than light people. In the world of work, however, most tasks primarily require the movement of objects external to the worker's body. Thus, the relationship of body weight to muscular capability directed toward external objects is of considerable occupational interest. From Navy entry data (see Table 3 correlations for men and Table 4 for women in Robertson, 1982), five measures of body weight were analyzed with eight measures of dynamic or static strength. The five measures of weight are: total body weight (WEIGHT), lean body weight, the ratio of fat to lean body weight (F/LBW), the ratio of weight to height (WT/HT), and fat body weight. The dynamic strength measures are the calisthenic type--sit-up, push-up, pull-up, and bent-arm hang; the static strength measures are handgrip, armpull, armlift; and the power measure is ergometer. Figure 5 displays the correlational relationship among these variables. As shown, all the body weight measures show a negative relationship with dynamic measures and a positive relationship with the static and power measures (except handgrip for women and sit-up for

Table 12

Significance Tests for Fairness of Separate or Combined Gender Groups Using a Moderated Multiple Regression Strategy[a]

Step	Step-up Procedure	Multiple Regression R	R^2	Change	F[b]	p<
Criterion Task: Tow-Bar Run Across Cable (Carry Task--V12) N = 424						
1	Predictor (V28)	.81	.654	.654	979.24	.01
2	Gender Term[c] (G)	.85	.719	.066	98.55	.01
3	V28 X G Interaction	.85	.720	.000	.33	(n.s.)[d]
Criterion Task: Fuel Hose Drag (Pull Task--V25) N = 375						
1	Predictor (V28)	.83	.688	.688	953.29	.01
2	Gender Term[c] (G)	.85	.728	.040	55.68	.01
3	V28 X G Interaction	.86	.732	.005	6.59	.05
Criterion Task: Power Cable Rig (Pull Task--V26) N = 411						
1	Predictor (V28)	.83	.692	.692	971.77	.01
2	Gender Term[c] (G)	.84	.700	.008	11.51	.01
3	V28 X G Interaction	.84	.710	.011	14.95	.01

[a]Bartlett et al. (1978).

[b]F test for hierarchical decomposition method (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975, p. 337).

$$F = \frac{R^2 \text{ change, Step } n_{1...3}}{\dfrac{(1 - R^2, \text{Step}_3)}{(N - N \text{ predictors} - 1)}}$$

[c]Gender Term: Men = 2; Women = 1.

[d]n.s.--not significant at .05 level.

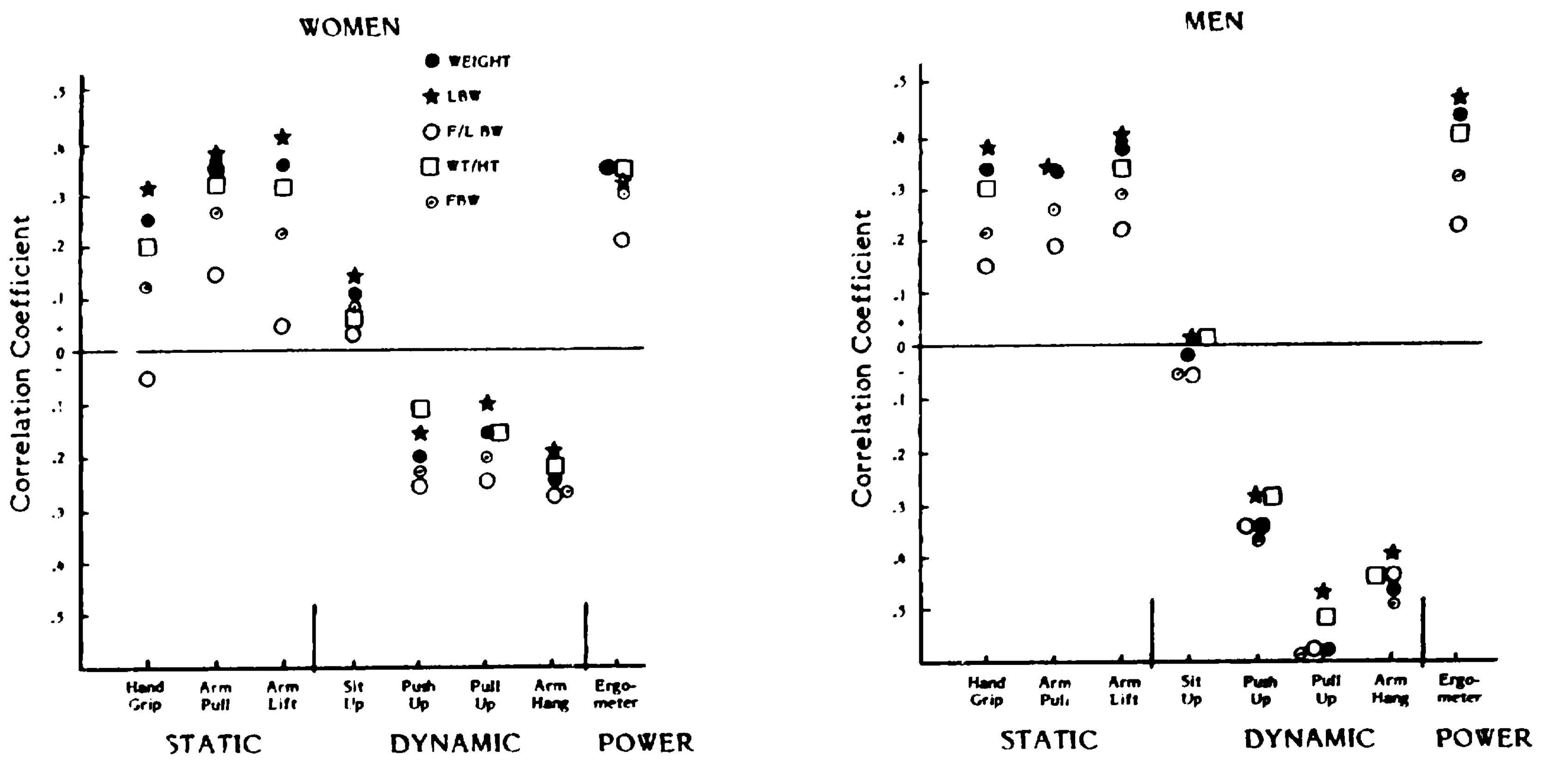


Figure 5. Strength and body weight relationships (from Robertson, 1982, Tables 3 and 4).

both men and women). This finding is consistent with the results of the present research that show body weight and armpull to be good correlates of both shipboard and occupation-specific tasks (in handling heavy objects with little appreciable movement of the body), but conversely, show dynamic measures such as calisthenics and swimming to be the better predictors where rigorous movement of the body is involved (Robertson & Trent, 1983). Thus, the larger, heavier people, including those with the higher fat body weight, are more capable of handling heavy objects aboard ship or in the occupation-specific jobs.

Benefits from Physical Conditioning

The gains from a physical conditioning program lend strong support to the discount procedure that was employed in the impact analysis. That is, the average scores, for both men and women, tend to be higher, and thus more predictable, at the end of recruit training than at the beginning. By using expected gains, smaller percentages are excluded in the impact analysis. It is important to emphasize, however, that these gains are not consistent across the entire distribution of a test, that in fact, given a routine conditioning program, the gains will be higher among those that most need the program (the least fit); and the most fit may even show losses (Robertson, 1982).

Further Usefulness of Data Base on Muscularly Demanding Tasks

The occupational and shipboard tasks illustrated in Tables 2 and 3 are just a few of the many tasks that are documented and available in the data base. Furthermore, tasks can be retrieved for any category, or combination of categories, for a variety of task types by ship or squadron, rating, BBE, etc. Although estimates of push/pull forces in the data base are not very useful (see Criterion Task Selection), other data (e.g., for effort, weighted sum (WTSUM)) can identify the most muscularly demanding tasks for any type of job. The data can serve as a starting point for follow-up projects to identify opportunities to modify equipment or tasks and reduce a job's physical demands.

CONCLUSIONS

1. A survey and a data base of muscularly demanding tasks were quite useful as starting points to identify specific criterion tasks and can be further useful in other projects that address physical demands.

2. Simulated tests of muscularly demanding tasks have some advantages over administration of the actual task aboard Navy combat ships. The simulated tests are safer and more efficient. They did not require use of operational equipment, and they did not interfere with operational crews.

3. An STB is a valid indicator of the capability to perform muscularly demanding shipboard and occupation-specific tasks. Some of the best correlates of shipboard performance are armpull, ergometer, and body weight.

4. Procedures to determine STB cut-scores, however, vary in percentages of personnel excluded. One method, the rectangular one, is less severe in percentages of women excluded and, thus, may be the most useful to implement.

REFERENCES

Arnold, J. D., Rauschenberger, J. M., Soubel, W. G., & Guion, R. M. (1982). Validation and utility of a strength test for selecting steel workers. Journal of Applied Psychology, 67(5), 588-604.

Bartlett, C. J., Bobko, P., Mosier, S. B., & Hannan, R. (1978). Testing for fairness with a moderated multiple regression strategy: An alternative to differential analysis. Personnel Psychology, 31, 233-241.

Davis, P. O. (1976). Relationships between simulated fire fighting tasks and physical performance measures (Doctoral dissertation from University of Maryland). Ann Arbor, MI: University Microfilms International.

Flanagan, J. C. (1951). Units, scores, and norms. In E. F. Lindquist (Ed.), Educational Measurement. Washington, DC: American Council on Education.

Fleishman, E. A. (1964). The structure and measurement of physical fitness. Englewood Cliffs, NJ: Prentice-Hall.

Fleishman, E. A., Dremer, D. J., & Shoup, G. W. (August 1961). The dimensions of physical fitness--A factor analysis of strength tests (Yale University Tech. Rep. 2). Office of Naval Research.

Gulliksen, H., & Wilks, S. S. (1950). Regression tests for several samples. Psychometrika, 15(2), 91-114.

Laubach, L. L. (May 1976). Muscular strength of women and men: A comparative study (AMRL-TR 75-32). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command.

McDaniel, J. W., Skandis, R. J., & Madole, S. W. (May 1983). Weight lift capabilities of Air Force basic trainees (AFAMRL-TR-83-0001). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force System Command.

Myers, D. C., Gebhardt, D. L., Crump, C. G., & Fleishman, E. A. (January 1984). Validation of the military entrance physical strength capacity test (MEPSCAT) (ARI-TR-610) (Contract NO. MDA 903-82-C-0140). Alexandria, VA: Army Research Institute for Behavioral and Social Sciences.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. (1975). Statistical package for the social sciences (SPSS) (2nd Ed.). New York: McGraw-Hill.

Robertson, D. W. (April 1982). Development of an occupational strength test battery (STB) (NPRDC Tech. Rep. 82-42). San Diego: Navy Personnel Research and Development Center. (AD-A114 247)

Robertson, D. W., & Trent, T. (October 1983). Validity of an occupational strength test battery (STB) for early identification of potential underwater demolition team and sea/air/land team trainees (NPRDC Tech. Rep. 84-2). San Diego: Navy Personnel Research and Development Center. (AD-A134 326)

Tenopyr, M. L. (March 1977). Physical proficiency tests as predictors of outside craft performance: Executive summary. Basking Ridge, NJ: Employment Research Group, American Telephone and Telegraph.

Tilton, J. W. (1937). Measurement of overlapping. Journal of Educational Psychology, 28, 656-662.

Van Naerssen, R. F. (1965). Application of the decision-theoretical approach to the selection of drivers. In Cronbach, L. J., & Gleser, G. C., Psychological tests and personnel decisions. Urbana: University of Illinois Press.

APPENDIX A

EXCERPTS FROM SURVEY OF MUSCULARLY DEMANDING TASKS

EXCERPTS FROM SURVEY OF MUSCULARLY DEMANDING TASKS

Types of Surveys to Document Muscularly Demanding Tasks

Because no data base existed for an analysis of muscularly demanding Navy jobs, it was necessary to design two basic surveys--one for rating/NEC-specific incumbents and one for command unit representatives to identify common unit tasks that extend across ratings or departments. These surveys were administered by mail

Each of the two basic forms had three sections: (1) instructions and BBE examples, (2) a detailed format, and (3) a brief format. The rating-specific form also had a section for background and injury experiences.

Rating NEC-specific (by incumbent)

The incumbent form included: instructions and examples (pp.A-2 to A-4); background questions (pp. A-5 to A-6); and task with greatest muscular demands--brief (pp. A-7 to A-8) and detailed format (pp. A-9 to A-14).

Common Ship/Shore Tasks (by unit representative)

Excerpts from the command form included: instructions (pp. A-15 to A-16); tasks with greatest muscular demands detailed format (pp. A-16 to A-17, and A-10 to A-14) and duty status brief format (pp. A-18 to A-19).

GENERAL INSTRUCTIONS

You have been selected, as a representative of your Rating, to help us collect task analysis information on the most physically demanding tasks of your present job. You are the expert. Tell us what the most demanding tasks are, and the details of the effort related to the tasks. If all of your job tasks require little or no muscular effort, we still need you to provide some information.

With your help, the Navy Occupational Task Analysis Program can: (1) Determine whether some physical demands might be too physically limiting for some recruits to enter the Rating, (2) identify better ways to distribute the effort with better team applications, and (3) redesign materials or equipment to reduce the physical demands.

USING YOUR MUSCLES ON THE JOB

Before getting to the specific questions, let's consider the different ways that we use our strength. Sometimes the most demanding tasks are those that require the greatest muscular force when something is first moved (for example, lifting/carrying/installing a 70 pound box or component); and other tasks are muscularly demanding because of continuous or repeated effort (for example, using a 2 pound hammer, or turning a crank or lever arm which requires 15 pounds force/"push" to turn it). Comparing the examples of the box and the hammer, it takes little effort to pick up a 2 pound hammer, but if it is swung, let's say, 50 times in a minute, that's a total lifting of 100 pounds (with only one arm), compared to the 70 pound box.

Also, keep in mind that the greatest effort in some of your tasks may have to be applied, not because of the weight of the object moved, but because of some limiting position of your body while performing the task. For example, we cannot exert as much push or pull force with our arm or leg muscle nearly/fully bent as we can with it nearly straight.

The farther away from our body we must hold something, the less weight we can lift. Also, the opportunity to get a good grip or hold on an object can make a big difference on how effective our use of muscular force is.

And still another difference is between INITIATING and SUSTAINING forces to do some tasks. For examples, to respot an aircraft on the flight deck, the push force necessary to start ("initiate") the aircraft rolling, is greater than the force to keep ("sustain") it rolling; and to loosen a corroded bolt of a motor mount, the force for the initial turning of the wrench is greater than for the continuing ("sustaining") turning.

The muscular demands of just about all job tasks can be described by one or more of the eleven types of Basic Body Effort (BBE) below.

Type of Basic Body Effort (BBE)	Task Examples
1. LIFT-WITHOUT CARRY	Lift box/part onto shelf or truckbed. Lift box/part from cart/rack to workbench.
2. CARRY-WALKING	Carry stores/ammo. Carry motor to shop for overhaul.
3. CARRY-RUNNING/ SWIMMING	(Does not include "carry only yourself" to, for example, your battle station. Does include carry a component necessary for your job.) Carry can of foam to scene of fire. Recover launch bridle.
4. PUSH-REPETITIVE	"Pump" auto jack handle. Push handsaw.
5. PUSH-DISTANCE	Start to push aircraft. Close hanger door.
6. PULL	Remove armature from motor. Maintain tension on handling line. Drag hose into position.
7. SQUEEZE	Use metal cutting shears.
8. TURN-LEVER	Wrench to loosen corroded mounting bolts. Crank, at emergency steering station, to shift rudder.
9. TURN-WHEEL	Lock water-tight door. Close water main. Connect hose sections.
10. SWING-REPETITIVE	Pound with hammer. Dig with pickax. Dig with shovel.
11. SWING-DISTANCE	Throw grenade. Toss rivet. Throw coil of line.

Notice that BBE types 1-6 usually involve efforts to move something in a straight line--lift up, or carry/push parallel to the deck--while BBE's 8-11 involve curved/arc/torquing type efforts.

Some job tasks may involve only one activity and one of the above BBE types, while other tasks may involve several. For example, consider the phases (A-D) of effort (by 2 persons) to repair a Lube Oil pump, described by a MM3: A. Remove deck plates, each plate up to 40 pounds each (BBE 1); B. Remove foundation bolts (sometimes corroded, need pipe extension as lever on wrench, cramped space in bilge) (BBE 8); C. Lift 150 pound pump 4-6 feet from bilge to deck (BBE 1); and D. If chain fall not available, 2 persons carry pump up ladders (BBE 2).

Here's another example, described by a HTC, to setup and operate a portable pipe bender. A. Carry bender components (dies, pump, brackets) from storage area to center of ship's shop (about 15-20 feet). Pump component is the heaviest part, about 100 pounds, and remaining parts weight about 300 pounds total (BBE 2). Usually, 2 people set up the bender. B. To setup, connect fitings and fasten equipment together (no tools needed) (BBE 1). C. Carry and lay pipe onto dies--pipe can weigh 200 pounds, 10 feet long, 3½ inch pipe (BBE 2). Usually, 2 people carry, and if carried down ladder, 2 additional people help. D. Manually pump ram into die to bend the pipe (BBE 4).

SPECIFIC INSTRUCTIONS

You are asked to identify the most demanding tasks directly related to your (1) Rating, and (2) other tasks of your present job which are military, special or work party duties. Because of the great variety of tasks in Navy billets, there can be great differences between the physical demands of the Rating and the other duties of a billet, especially at sea. We need the data for both kinds to ensure that the job gets done.

Also, some demanding tasks may be performed daily; but others, just as essential, performed seldomly--maybe only a few times a year during battle drills, or in an actual emergency or combat condition. You should consider both daily and special situations when identifying the most demanding tasks.

Please do not identify demanding tasks simply because you may have felt fatigued as a result of long hours or days on the job. In other words, identify the task for which your muscular strength is directly applied.

Here is an overview of the kinds of information needed from you:

Step 1: Complete the 6 items of background information.

Step 2: For your Rating, brief information on 11 of your most demanding job tasks--one task for each of the 11 BBE's.

Step 3: For your Rating, more detailed information on your 2 most demanding tasks.

Step 4: Of your military or special duty assignments (shipboard or station tasks outside your Rating), detailed information on your most demanding task.

You are now ready to provide the information for each Step.

Step 1 BACKGROUND INFORMATION

1. [ ] Your present duties are most closely related to your:

   0. Rating
   1. Primary NEC
   2. Secondary NEC
   3. Third NEC
   4. (None of the above)

2. Your Division type or title: ______________________________

3. Your height [ ] feet and [ ][ ] inches

4. Your weight [ ][ ][ ] pounds

5. [ ] From performing any Rating/NEC/military job or training task, have you ever experienced any pulled/strained/sore muscle or bone discomfort from performing the task?

   0. Never
   1. Occasionally, but not bad enough to report to Sick Call.
   2. Occasionally, and reported to Sick Call, but light duty chit wasn't necessary.
   3. Occasionally, and was put on light duty status.
   4. Frequently, but light duty status wasn't necessary.
   5. Frequently, with some resulting light duty.
   6. Yes, with some resulting hospitalization.

   What was the task(s) and location of the discomfort (if "never," leave blank)?

   Task(s) ______________________________

   ____

   Location of discomfort ______________________________

   ____

6. ☐ From your recreation/leisure (civilian or Navy) activities, or from a previous civilian job task, have you ever experienced any pulled/strained/sore muscle or bone discomfort from the activity?

0. Never
1. Occasionally, but not bad enough to report to Sick Call.
2. Occasionally, and reported to Sick Call, but light duty chit wasn't necessary.
3. Occasionally, and was put on light duty status.
4. Frequently, but light duty status wasn't necessary.
5. Frequently, with some resulting light duty.
6. Yes, with some resulting hospitalization.

What was the activity and location of the discomfort (if "never," leave blank)?

Activity ____

____

Location of discomfort ____

____

Step 2--Next, complete the BBE Data form. (Even if your most demanding job tasks require little muscular effort, for examples, possibly in some administrative or technician jobs, we need to know what these light tasks are also.)

BBE DATA

Describe Your Rating Tasks With Greatest Muscular Demands--1 Task for Each Type of BBE

1. Fill in each block of columns I-VII.
2. If for one of the BBE's, absolutely no task in your Rating relates, write "none" in that block of column I.

Type of Basic Body Effort (BBE)	I Write a brief description of object moved and what is done with it. Where possible, include name or model of a tool or equipment. If more space is needed, continue on back side. (See Note 1 on back)	II Estimated pounds (lbs) force that you apply (See Note 2)	III Demands on your strength (Circle code from Note 3)	IV For repetitive type tasks, movements per minute	V For distance type tasks, distance or turns the object is moved	VI Number of workdays per year that this task typically is performed (See Note 4)	VII On days performed, total minutes typically performed within 8 hour work period (See Note 5)
1. LIFT--Without Carry		lbs force	0 1 2 3 4 5	Lifts per min.	inches	workdays	minutes
2. CARRY--Walking		lbs force	0 1 2 3 4 5		feet	workdays	minutes
3. CARRY--Running/Swimming		lbs force	0 1 2 3 4 5		feet	workdays	minutes
4. PUSH--Repetitive		lbs force	0 1 2 3 4 5	Cycles per min.		workdays	minutes
5. PUSH--Distance		lbs force	0 1 2 3 4 5		feet	workdays	minutes
6. PULL		lbs force	0 1 2 3 4 5		feet	workdays	minutes
7. SQUEEZE		lbs force	0 1 2 3 4 5	Closures per min.		workdays	minutes
8. TURN--Lever		lbs force	0 1 2 3 4 5		turns	workdays	minutes
9. TURN--Wheel		lbs force	0 1 2 3 4 5		turns	workdays	minutes
10. SWING--Repetitive		lbs force	0 1 2 3 4 5	Swings per min.		workdays	minutes
11. SWING--Distance		lbs force	0 1 2 3 4 5		feet	workdays	

BBE DATA

<u>NOTES</u>:

1. For ideas, you might want to refer back to the BBE examples on pages 2 and 3. Please be specific. It is important that we know exactly what job task, tool, and equipment you are describing.
2. This is sometimes difficult to estimate, but please give your best estimate. (It is planned to follow-up on some force estimates using precise measuring instruments.)
3. In moving the object described for each BBE task, circle the code number that describes the physical demands on <u>your</u> strength as:
   0. So easy that it requires practically no effort at all.
   1. Requires some effort, but still quite easily within <u>your</u> capabilities.
   2. Although demanding, is still within <u>your</u> capabilities.
   3. Pushes the very limits of <u>your</u> capabilities--you are barely able to move the object(s) to perform the task.
   4. Sometimes exceeds <u>your</u> strength capabilities.
   5. Usually exceeds <u>your</u> strength capabilities.
4. This might be any number of workdays up to a maximum of a' ut 225 (after weekends, holidays, sick days, and leave are subtracted from a calendar year)--but possibly a higher number to include some sea duty workweeks.
5. Your number of minutes would, of course, be some number between 001 and 480, dependent upon necessary rest periods and performing other tasks.

Continuation of column 1. (Brief description of task.)	
1. LIFT--Without Carry	
2. CARRY--Walking	
3. CARRY--Running/Swimming	
4. PUSH--Repetitive	
5. PUSH--Distance	
6. PULL	
7. SQUEEZE	
8. TURN--Lever	
9. TURN--Wheel	
10. SWING--Repetitive	
11. SWING--Distance	

Step 3--Next, we ask for information in greater detail for your 2 most demanding Rating-related tasks. Please complete the following two 27-item forms for each task, IF the task requires a Code 2, 3, 4 or 5 physical demands on your strength. (If absolutely none, or only one, of your tasks requires one of those levels of physical demand, leave one or both of these forms blank and go to Step 4.)

Note that: (1) Your first, most demanding task, should be from one of your BBE's in Step 2; and (2) your second most demanding task would be from, either another BBE or a new/different task in the same type BBE as your first most demanding task. (Because of this latter possibility, some of the basic questions of Step 2 are repeated in this more detailed form.)

RATING RELATED TASK WITH GREATEST MUSCULAR DEMANDS

1. In the box below, please describe the specific object/tool/control moved and what is done with it. Where possible, include name or model of a tool or equipment.

(If more space is needed to describe task, continue on back of this page.)

2. ☐ Type of object moved (write the code number in the box):

0. Consumable materials	5. Tool
1. Replacement part	6. Lever
2. Component part	7. Valve/wheel
3. Whole weapon/system/craft	8. Line/hose
4. Person (example: patient)	9. Other: ______________

3. ☐ In moving this object, the physical demands on your strength could be described as

0. So easy that it requires practically no effort at all.
1. Requires some effort, but still quite easily within your strength/grasp capabilities.
2. Although demanding, is still within your capabilities.
3. Pushes the very limits of your capabilities--you are barely able to move the object(s) to perform the task.
4. Sometimes exceeds your strength capabilities.
5. Usually exceeds your strength capabilities.

> If you marked 0 or 1 above, STOP; go to Step 4.
>
> If you marked 2, 3, 4, or 5, CONTINUE with Questions 4-27.

4.

A

No. of persons usually teamed together to exert the force to do the job:

☐☐ persons

B

Estimate pounds force exerted by only you, in one effort or one repetition, for example if lifting 85 pound box, fill in [0|8|5]; if swinging 2-pound hammer, fill in [0|0|2]:

☐☐☐ pounds

5. For one complete move/use of the above object/tool:

A. Time/duration that your effort is applied ☐☐☐ minutes plus ☐☐ secc

B. Distance that the object/tool is:
moved/carried ☐☐☐☐ feet plus ☐☐ inches

C. Height object/tool (complete only one line)

Raised ☐☐☐ feet plus ☐☐ inches
or
Lowered ☐☐☐ feet plus ☐☐ inches

6. ☐ Frequency of one/each move/use:

0. More than 50 times per day
1. 13-50 times per day
2. 6-12 times per day
3. 1-5 times per day
4. 1-4 times per week
5. 1-4 times per month
6. Seldom

7. ☐ Regularity of performing this task:

0. Regularly at the above frequency
1. The above frequency only applies during particular operations/conditions as indicated in Questions 8 and 11 below.

8. ☐ Deployment status when task most typically performed (mark only one):

0. Shore Station
1. Underway group Ops
2. ISE
3. Mooring or getting underway
4. In Port
5. In Overhaul

9. ☐ The strength requirements to perform this task are:

0. Greater at sea
1. Greater ashore
2. About the same at sea or ashore

10. ☐ The work activities required to perform this task are:

0. More applicable at sea
1. More applicable ashore
2. About the same at sea or ashore

11. ☐ Operating Conditions:

0. Regular working hours
1. Watch Standing
2. Battle condition
3. Emergency or Emergency Drill
4. Special evolution (for example, underway replenishment, special sea detail, etc.)

12. This task is most typically performed by which pay grade(s)?

E-2 E-3 E-4 E-5 E-6 E-7 E-8 E-9

Typically, from ☐ to ☐

Lower Pay Grade — Higher Pay Grade

(Answer only Question 13 or 14)

13. If your effort is applied to an attached line/control/valve/lever/et.--describe the dimensions (below) which are applicable:

A. Lever-- Length ☐☐ inches

No. of times activated ☐☐ to move object for one complete move/use

B. Wheel/valve--radius (equals ½ of its diameter) ☐☐ inches

C. Line/hose--Thickness ☐.☐ inches

(decimal point)

Length ☐☐☐ feet

14. ☐ If your effort is applied to a movable object (examples--carrying box, pushing aircraft, etc.), indicate how it is moved--by:

0. Rolling
1. Sliding/dragging
2. Carrying/lifting
3. Other: ____________________
4. (Not applicable for fixed object described above)

15. ☐ Body activity/application while applying the greatest effort to the object:

0. Moving--walking
1. Moving--running
2. Moving--climbing
3. Moving--crawling
4. Stationary--standing
5. Stationary--sitting
6. Stationary--lying
7. Stationary--stoopi (bending at knees
8. Stationary--bowing (bending at waist)

16. ☐ Grip applied:

0. Finger tip(s) only
1. One hand
2. Both hands

17. ☐ Type Basic Body Effort (BBE) applied:

1. Lift-without carry
2. Carry-walking
3. Carry-running/ swimming
4. Push-repetitive
5. Push-distance
6. Pull
7. Squeeze
8. Turn-lever
9. Turn-wheel
10. Swing-repetitive
11. Swing-distance

18. ☐ This task is difficult to perform partly because of the GRIP (to hold/ move/use the object), which is:

0. Very difficult to hold/grasp
1. Fairly difficult to hold/grasp
2. Slightly difficult to hold/grasp
3. (No problem to hold/grasp)

19. ☐ This task is difficult to perform partly because of the CRAMPED/RESTRICTED SPACE which restricts body leverage:

0. Considerably
1. Fairly
2. Slightly
3. (Not at all)

20. ☐ This task is difficult to perform partly because of the REACH (to move/ use/remove/install the object) which is:

0. Considerable
1. Moderate
2. Slight
3. (Not applicable)

(Note: The following Questions 21-25 request special information for "<u>sustained</u>" [continuous or repetitive] type tasks.)

21. <u>If</u> the effort is from <u>frequent</u> repetition:

A. Indicate the usual number of repetitions <u>without</u> (or before) pausing relaxing, or resting ☐☐☐ and the time it takes to perform this number of repetitions-- ☐☐☐ minutes plus ☐☐ seconds

B. The distance the object is moved in <u>one</u> repetition-- ☐☐☐ feet plus ☐☐ inches

C. (Check in box ☐ if effort does not involve frequent repetition.)

22. <u>If</u> the effort is a <u>continuous</u> type:

A. Duration of the effort <u>without</u> (or <u>before</u>) pausing, relaxing, or resting-- [ ][ ][ ] minutes plus [ ][ ] seconds

B. Distance that the object is moved in one continuous effort (before pausing)-- [ ][ ][ ][ ] feet plus [ ][ ] inches

C. (Check in box [ ] if effort is not continuous.)

23. On days when this task is performed, the <u>total</u> time within an 8-hour (480 minutes) work period that the task is typically repeated or continued, is-- [ ][ ][ ] minutes

24. For the conditions you marked in above Questions 10 and 11 how many days per year is the task typically performed? [ ][ ][ ] days

25. [ ] If the task is fatiguing, what environmental condition <u>primarily</u> affects your fatigue?

0. (Not at all fatiguing)
1. High temperature
2. Low temperature
3. Noise/vibration
4. Motion (of craft)
5. Restricted space
6. Restricted movement
7. Rain/snow
8. Wind
9. Other: ____________

26. [ ] Have you ever experienced any pulled/strained/sore muscle or bone discomfort from performing <u>this task</u>?

0. Never
1. Occasionally, but not bad enough to report to Sick Call
2. Occasionally, and reported to Sick Call, but light duty chit wasn't necessary
3. Occasionally, and was put on light duty status
4. Frequently, but light duty status wasn't necessary
5. Frequently, with some resulting light duty
6. Yes, with some resulting hospitalization

27. Do you have any suggestions for redesign of this object/tool/control/task to reduce the muscular strength demands? ______________________________

____

____

____

____

Physical Demands
Data (C)
NAVPERS R&D CTR
San Diego

INSTRUCTIONS TO PARTICIPATING COMMAND:

This form is used to collect data regarding the greatest muscular demands of military, general or special duties (shipboard or station tasks outside of a particular Rating/NEC) in your command. Please assign this form for completion to a Department or Division Officer who is knowledgeable of such tasks, or can contact various divisions who perform these tasks.

- -

From: Participating Command
To: ______________________
(Assigned Dept./Div.)

1. Delivered for completion of the information indicated.

- -

GENERAL INSTRUCTIONS

As the designated representative of your command, you are asked to assist us in collecting task analysis information on the most muscularly demanding military or general tasks which are performed in the operation or support of your ship or station. (Other members of your command are providing the data regarding specific Rating/NEC related muscular demands.) You are the expert. Tell us what the most demanding tasks are, and the details of the effort related to the tasks.

With your help, the Navy Occupational Task Analysis Program can: (1) Develop objective measures of the physical demands, (2) identify better ways to distribute the effort with better team applications, and (3) redesign materials or equipment to reduce the physical demands.

SPECIFIC INSTRUCTIONS

1. Please confer with other Departments/Divisions to identify a preliminary list of the most muscularly demanding military/general/special duty tasks (i.e., outside of a particular Rating or NEC) which are performed in the operation or support of your ship or station.

2. Select the 3 tasks which you determine to be the most demanding. With the assistance of members who actually perform the tasks, complete one of the 26-item forms for each of the 3 tasks.

   (Note: Although the primary requirements of this phase of task data acquisition is to identify the 3 most demanding tasks of your type ship/station, it is realized that some commands perform operations involving several extremely demanding tasks. Thus, 2 extra sets of the 26-item form are attached to describe, at your option, 2 more of your most demanding tasks.)

3. SHIPS ONLY: On the Shipboard Duties Form, organized by type function, provide the brief information requested--the 2 most demanding tasks for each of 4 types of duty. (Note: If any or all of the 3 tasks in the detailed forms are within these types, you may use/enter these again in this brief format.)

4. Return all completed packet materials to the appropriate office of your command.

- -

Some demanding tasks may be performed daily; but others, just as essential, performed seldomly--maybe only a few times a year during battle drills, or in an actual emergency or combat condition. You should consider both daily and special situations when identifying the most demanding tasks.

Please do not identify demanding tasks simply because personnel may feel fatigued as a result of long hours or days on the job. In other words, identify the task for which their <u>muscular</u> strength is directly applied.

<u>Note</u>. Most of these questions in the unit command (common tasks format; see pp. A-16 to A-17) were identical to the rating/NEC-specific format and were not repeated -- questions 1, 2, 5-11, 13-15, and 27 (see pp. A-9 to A-14).

TASK WITH GREATEST MUSCULAR DEMANDS -- QUESTIONS UNIQUE TO COMMON SHIP/ SHORE DETAILED FORMAT:

3\.

A

No. of persons usually teamed together to exert the force (on <u>one</u> object) to do the job:

[ ][ ] persons

B

Estimate pounds force exerted by <u>only one</u> person, in one effort or one repetition, for examples, if lifting 85 pound box, fill in [0][8][5]; if swinging 2-pound hammer, fill in [0][0][2]:

[ ][ ][ ] pounds

C

Total no. of the command's personnel usually participating in this task at any one time/evolution, for example, for 4 line handling stations, and 7 persons per station would be [0][0][2][8]:

[ ][ ][ ][ ]

4. To move the object described above (in Question 1), considering the strength differences among the members of the crew performing this task, indicate approximately what percentages of the crew are capable of each of the levels of muscular effort (for example, 40% at Code 2, 50% at Code 3 and 10% at Code 4, would total 100%):

0. [ ][ ] % So easy that it requires practically none of their effort at all.

1. [ ][ ] % Requires some effort, still quite easily within their strength/grasp capabilities.

2. [ ][ ] % Although demanding, is still within their capabilities.

3. [ ][ ] % Pushes the very limits of their capabilities--they are barely able to move the object(s) to perform the task.

4. [ ][ ] % Sometimes exceeds their strength capabilities.

5. [ ][ ] % Usually exceeds their strength capabilities.

[1][0][0] (Total %)

12. This task is most typically performed by:

A

Pay Grades, typically

from [ ] to [ ]

Lower Pay Grade — Higher Pay Grade

B

Ratings/NEC's participating (check/complete only one.

[ ] All, or nearly all, Ratings/NEC's assigned to this command, within the pay grades indicated.

[ ] Usually, only the following (list the abbreviations of the Ratings or 4-digit codes of the NEC's): ____________________

____

____

____

SHIPBOARD DUTIES BRIEF SHEET

Describe the 1st and 2nd Most Muscularly Demanding Tasks, in Terms of a BBE, for Each Type of Duty

Fill in each block of Columns I-VI

Type of General Shipboard Duty		Write a brief description of object moved and what is done with it. Where possible, include name or model of tool or equipment. If more space is needed, continue on back side. (See Notes on back)	II Type BBE applied (Enter a code no. from page 2.)	III Estimated pounds (lbs) force that one person applies to the object	IV No. of persons teamed together on one object	V Number of workdays per year that this task typically is performed (See Note 1.)	VI On days performed, total minutes typically performed within 8 hour work period (See Note 2.)
Working Parties	1st			lbs force		workdays	minutes
	2nd			lbs force		workdays	minutes
DETAILS-- Rearming, Refueling, Replenishment	1st			lbs force		workdays	minutes
	2nd			lbs force		workdays	minutes
EVOLUTIONS-- GQ, Damage Control, Casualty Control	1st			lbs force		workdays	minutes
	2nd			lbs force		workdays	minutes
Inport Emergency Parties	1st			lbs force		workdays	minutes
	2nd			lbs force		workdays	minutes

SHIPBOARD DUTIES
BRIEF SHEET

NOTES:

1. This might be any number of workdays up to a maximum of about 225 (after weekends, holidays, sick days, and leave are subtracted from a calendar year)--but possibly a higher number to include some sea duty workweeks.

2. Your number of minutes would, of course, be some number between 001 and 480, dependent upon necessary rest periods and performing other tasks.

		Continuation of Column 1. (Brief description of task.)
Working Parties	1st	
	2nd	
DETAILS--Rearming, Refueling, Replenishment	1st	
	2nd	
EVOLUTIONS--GQ, Damage Control, Casualty Control	1st	
	2nd	
Inport Emergency Parties	1st	
	2nd	

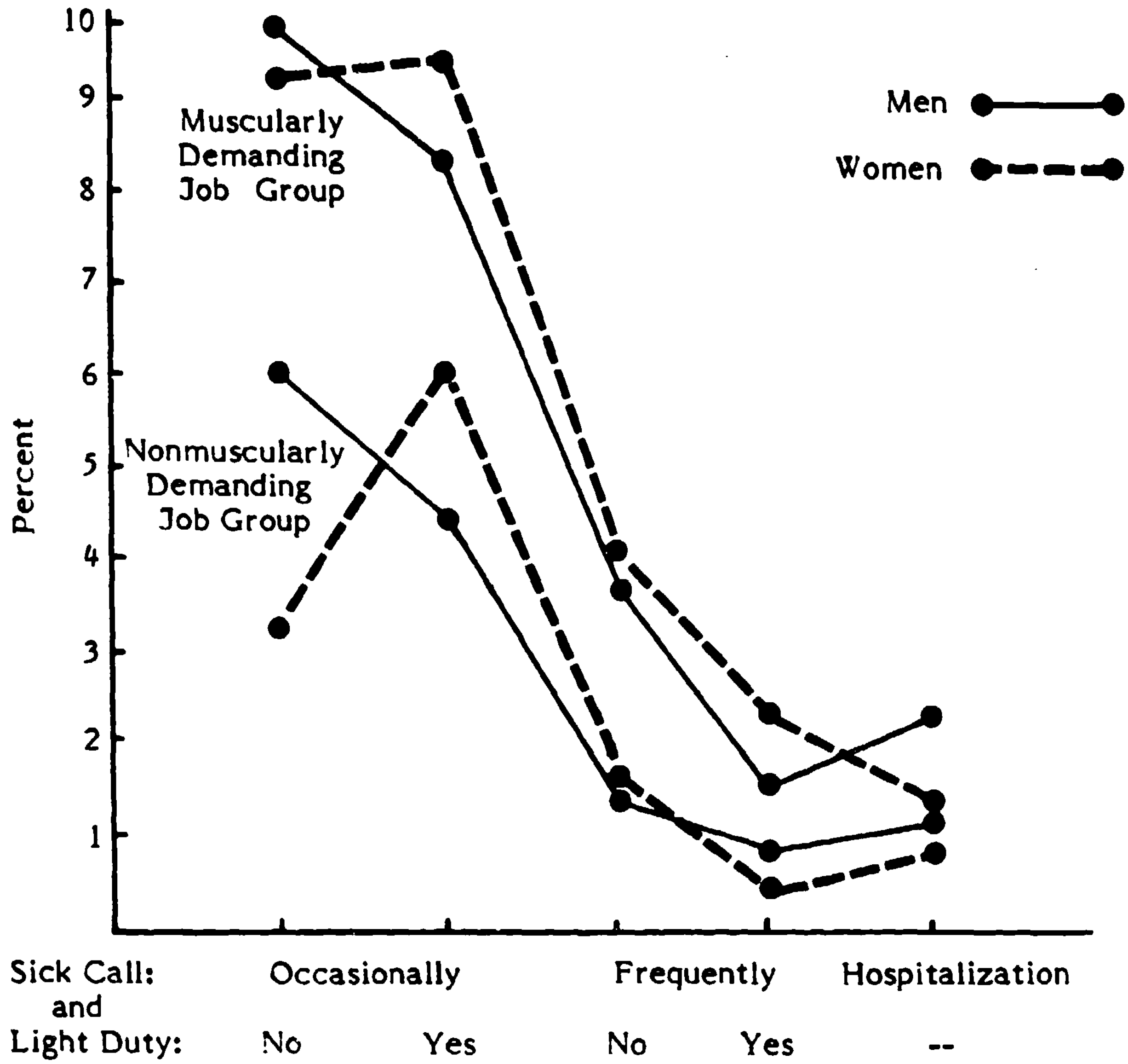


Figure A-1. Sick call and light duty/hospitalization experiences by job group. (N = 1059 men and 334 women for muscularly demanding group; N = 498 men and 495 women for other group. See p. A-5 for item 5 in survey.

APPENDIX B

OCCUPATION-SPECIFIC TASK TESTING PROCEDURES AND PERFORMANCE STANDARDS

OCCUPATION-SPECIFIC TASK TESTING PROCEDURES AND PERFORMANCE STANDARDS

Sequence

All tests were administered to the subjects (hereafter "S") during six 1-hour periods, with no more than two periods in one day. The STB measures (variables V1-V9) were administered in the first period in a three-part sequence (randomly within the first and second parts): V1 and V2, V3-V6, V7-V9. Criterion tests (V10-V27) were administered in a random order in the other five periods.

Strength Test Battery (STB)

V1. Arm-Pull (ARMPL). Equipment: Use Chatillon Push/Pull Gauge TCG-250 or TCG-500 attached to a pull bar (see Robertson, 1982, Figure 1). Procedure: with one hand holding the bar, S braces the other hand on the vertical support without feet or toes touching the support. S exerts maximum pull (without jerking). Administer three trials for each hand in the sequence L, R, L, R, L, R. Score: Record pounds. Score is average of last four trials, 3 to 6.

V2. Arm-Lift (ARMLF). Equipment: Use Chattilon Dynamometer WT-10-500 or Chatillon Push/Pull Gauge TCG-500 attached to lift bar (see Robertson, 1982, Figure 3). Advance the gauge pointer to allow for the weight of the lift bar and chain. Procedure: S stands with feet slightly apart, straddling the cable and pully. Chain length is adjusted for S's height, with the lower edge of S's forearms horizontal (down at an angle of 10 degrees is permissible). S exerts maximum lift (without jerking) by flexing only at elbows (i.e., with back and legs straight, heels flat, and without moving/raising shoulders). Administer three trials. Score: Record pounds. Score is average of trials 2 and 3.

V3. Ergometer (ERGOM). Equipment: Use Monark Rehab Trainer, Quinton, Instrument, CO. Model 880 (see Robertson, 1982, Figure 4). Set brake resistance at 600 KPM. Set handle arms at shortest length (4 1/2 inches). Before each test, reset counter to zero. Procedure: S cranks rapidly (maximum effort) for 30 seconds. Score: Record number of revolutions.

V4. Height (HT). Score: Record inches (with shoes off).

V5. Weight (WT). Score: Record pounds (with S wearing light phyical training (PT) clothes and with shoes off).

V6. Sit-up (SITUP): Procedure: Another S holds S's ankles loosely (so S's heels may slide). S's knees are to be bent slightly (about 15 degrees, or to clear one fist under knee). S starts in horizontal position, hands clasped behind neck (not head). In the up position, S's back must be at least vertical, but need not be beyond vertical (i.e., need not touch knees with elbows). In horizontal position, both shoulder blades must touch deck. Score: Record number of sit-ups in 60 seconds.

V7. Incremental Lift Machine, Jerk (LMJRK). Equipment: Use USAF-designed Incremental Lift Machine (see Figure B-1) with 10-pound increments from 40 to 200. Brief S on how to perform an effective "jerk" lift--after standing erect with lift bar, by bending knees slightly and snapping weight to shoulder level. Then emphasize to S the difference between the "jerk" and "press" procedure--for press (and also for elbow lift), feet must remain flat and back straight, with no knee bend or jerk. With minimum load (40 pounds--carriage only), let S practice once on jerk and once on elbow lift. Then start S at load relative to Arm Pull score. Increase/decrease the weight for S's maximum capabilities on each of the three kinds of lifts. (Note: Starting weight for elbow lift will be lower than for jerk/head-top lift.) Procedures: S stands with feet flat between handle bar, and grips bar with palms down. With S's arms and back straight (only knees bent), S lifts bar and stands erect (thus holding the bar at "knuckle-height," i.e., arms hanging straight down). (This is the starting position for the jerk test.) S jerks maximum possible weight loaded on bar to shoulder level. (NOTE: These are Navy testing procedures and vary somewhat from Army and USAF procedures.) Score: Record pounds.

V8. Incremental Lift Machine, Press (LMPRS). Procedure: With S holding bar at shoulder level (starting position), and with feet flat and body erect (i.e., no jerk), S presses maximum weight on bar to head top. Score Record pounds.

V9. Incremental Lift Machine, Elbow (LMELB). Procedure: Having lowered the bar to deck, S regrips bar with palms up and raises bar to knuckle height, S stands erect (starting position). With back straight and feet flat (i.e., no jerk), S raises maximum weight by flexing arms to 90 degrees (until lower side of forearm is horizontal). Score: Record pounds.

Criterion Task Performance Tests (TPT)

Carry Tasks

V10. Drop-Tank Carry (DRPTK). Equipment: Use grip point device that simulates tail fin of drop-tank. Attach device to weight bar and carry cart (See Figure B-2). Load weights on cart to achieve 100 pounds at grip point. (This is one-half the load of the actual 2-person carrying task.) Procedure: S rapidly carries device 100 feet walking forward, and after about a 30 second rest, 100 feet back to starting point walking backward. S may walk rapidly but may not run. S may lower the device for brief rests, but S is advised that such rests affects the score. Score: Record separately the seconds for 100 feet forward and for 100 feet backward. Assign 90 seconds for incomplete if either carry exceeds that time, and also record distance (feet) carried. (See Table B-1 for work output (WKO) score.)

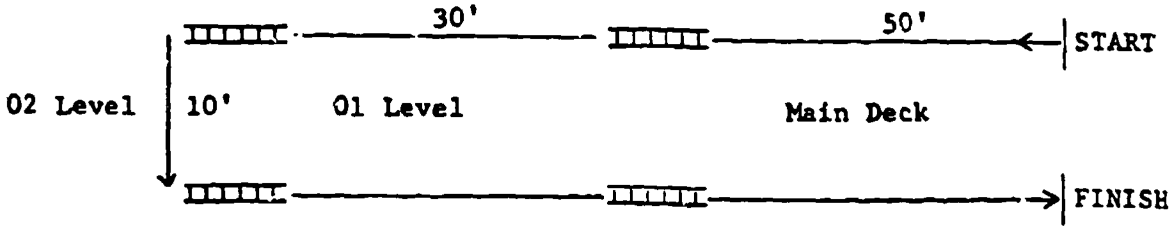
V11. Tow-Bar Run, Clear (TWB-C)Equipment: Use actual aircraft nose gear tow bar (See Figure B-3). Tongue weight at grip point is 62 pounds. Procedure: S rapidly carries/pulls bar at tongue point for 300 feet. S may lower bar for brief rests. Score: Record seconds. Assign 180 seconds for incomplete if carry exceeds that time, and also record distance (feet) carried. (See Table B-1 for WKO score).

V12. Tow-Bar Run, Across Cable (TWB-X). Equipment: Use same tow bar as for V11. Use 1 1/2" (outer diameter) pipe to simulate aircraft carrier flight deck cross-deck pendant (arresting cable) (See Figure B-3). Position pipes along 300-foot course at points (in feet) 25, 100, 175, and 250. S is shown technique to "tilt" or "jerk" tow bar over pipe, S then practices the technique. Procedure: S rapidly carries/pulls bar at tongue point for 300 feet, including crossing over the four simulated cables. S may lower bar for brief rests. Score: Record seconds. Assign 240 seconds if incomplete, and also record distance (feet) carried. (See Table B-1 for WKO score.)

V13. Fuel Probe or Acetylene Battery Carry (FP/AC). Equipment: Use grip point device that simulates the base of either object, a 12.5 inch diameter edge, 2 inches deep. (Actual tasks are: For fuel probe, a 3-person carry requiring 120 pound lift by 1 person at the cylindrical base; and for acetylene bottle, a 2-person carry requiring 114 pound lift by 1-person at the cylindrical base.) Attach device to weight bar and carry cart. Load weights on each cart to achieve, at the grip point, the following loads (pounds): 50, 69, 88, 114, 120 (See Figure B-4). S tries out, practices, and selects the heaviest weight that S is capable of carrying over the 100 foot course. Procedure: S rapidly carries device 50 feet walking forward, and after about a 30 second rest, 50 feet back to the start point walking backward. S may walk rapidly but may not run. S may lower device for brief rests. If S selected too heavy a weight to complete the course, S selects a lesser weight and is retested. Score: Record weight carried and seconds for each carry forward and backward. Assign 90 seconds for incomplete if either carry exceeds that time, and also record distance (feet) carried. (See Table B-1 for WKO score.)

V14. Crucible Pour (CRUCB). Equipment: Use grip point device that simulates 2-bar handling device to pour molten metal from crucible. Attach device to weight bar and carry cart, using the cart on a track that is designed for S walking sideways (See Figures B-5 and B-6) to simulate the procedures of the actual job task. (Actual task is 2-person carry, requiring 153 pound lift by 1-person.) Load weights on cart to achieve at the grip point the following alternative loads (pounds): 99, 130, 153, 168. S tries out, practices, and selects the heaviest weights that S is capable of carrying over the 40 foot course. Procedure: S rapidly carries device 20 feet walking/stepping sideways to left, and after about a 30 second rest, S carries device sideways 20 feet to right back to start point. On the second part of carry, S stops every 2 feet (10 stops) and rotates the handle bars clockwise 45 degrees (to simulate pouring the metal into the molds). S may walk rapidly but may not run, and may lower the device for brief rests. If S selected too heavy a weight to complete the course, S selects a lesser weight and is retested. Score: Record weight carried and seconds for each part (to the left and then to the right) of the carry. Assign 60 seconds for carry to left, or 120 seconds to right, for incomplete if either carry exceeded that time; and also distance carried to left, and number of "pours" to right. (See Table B-1 for WKO score.)

V15. 5-Gallon Can Carry (5GCAN). Equipment: Use 5-gallon cans weighted to the following alternative loads (pounds): 0(empty), 35, 45, 60, 75, 95. Set up the following course aboard a navy ship or recruit training ship: 170 feet level, up 2 ladders, down 2 ladders (all ladders are inclined, not vertical).



To become oriented on steep ladders, S practices by carrying an empty can over the total course. S then tries out and selects the heaviest weight that S is capable of carrying over the total course. Procedure: S carries can over total course. S may walk rapidly, but may not run, and must walk very carefully on ladders. S may lower the can for brief rests. If S selected too heavy a can to complete the course, S selects a lesser weight and is retested. Score: Record weight carried and seconds to complete the course. Assign 270 seconds for incomplete if carry exceeded that time, and also distance (feet) carried and number of ladders completed. (See Table B-1 for WKO score.)

V16. Equipment Carry (EQUIP). Equipment: Use grip point device that simulates a weapon system component or tool representative of heavy objects with "built-in" handles, carried by 1-person in ship passage-ways and ladders. The two devices used for this test simulate: A tactical information display (TID--an aircraft component "black box") weighing 70 pounds (See Figure B-7); and a hydraulic jack for aircraft landing gear, 119 pounds. Use part of the same course as for V15: 110 feet level, up and down one ladder (see V15 course). S tries out and selects the heavier of the two devices that S is capable of carrying over the course. Procedure and Score: (Same as for V15 except 150 seconds for incomplete.)

V17. Acetylene Bottle Carry, Ladder (ACETB). Equipment: Use same grip point device as for V13, but attach to carry cart designed to ride on tracks mounted on ship ladder (See Figure B-8). Load weights on cart to achieve one of the following alternative loads (pounds) at the grip point with the device positioned on the ladder: 88, 106, 133, 150. (The actual task is a 2-person carry of a total 225 pounds, but on ladder, the lower person carries 133 pounds.) S tries out, selects, and practices (on two steps) the heaviest weight that S is capable of carrying up 7 steps of the ladder. Procedure: S carries/pushes the device up 7 steps of ladder, then carries it back to the start point. S may step up rapidly, but must step very carefully. S may lower device for brief rests. If S selected too heavy a weight to complete the carry, S selects a lesser weight and is retested. Score: Record weight carried and seconds to complete 7 steps. Assign 45 seconds for incomplete if carry exceeded that time, and also number of steps completed. (See Table B-1 for WKO score.)

V18. Mark 82 Bomb Load (BOMBL). Equipment: Use bomb loading simulator (See Figure B-9). Load weights on lift bar to achieve alternative loads (pounds) of 30, 50, 70, 90, 120, 140, 160, 180. (The actual task is a 4 persons lift to the wing rack of an aircraft, 139 pounds lift by one person.) A 2-part technique is used. The 4-person lift the bomb to an intermediate level, and as 2 persons (one on each end) hold the loading bars, the other 2 persons shift to a grip that positions their shoulders below the loading bars, for a more efficient lift to the height of the wing rack.) The 2-part technique is simulated by S raising the loading bar to an intermediate rack, then shifting grip position and raising the bar to the top rack. S tries out and selects the greatest weight that S is capable of lifting to the top rack. Procedure: S raises load bar to mid-point rack, then to top rack. The test is repeated with the next greater weight until S can not raise the weight to the top rack, or until the greatest weight (180 pounds) is raised. If S can not raise a greater weight, the test is repeated with the previous weight. Score: Record greatest weight that S has raised twice.

V19. Canopy Raise, 1-Arm (CNPY1). Equipment: Use canopy raise simulator (See Figures B-10 and B-11). Load weights on weight bars to achieve alternative weights at the grip point (canopy handle) of (pounds) 22, 32, 54, 65, 76, 87, 98. (The actual task requires raising the canopy of an aircraft (manually), when the hydraulic system is not pressurized) with one hand and inserting a safety strut with the other hand, while in an awkward position on the inset steps of the fuselage, requiring a lift force of 57 or 63 pounds for two different A7 canopy designs.) S tries out, selects, and practices with the greatest weight that S is capable of raising. Procedure: S raises canopy handle with one hand and inserts safety strut with the other hand. Score: Record greatest weight that S could raise.

V20. Canopy Raise, 2-Arm (CNPY2). Equipment: Use same simulation as for V19, same alternative loads, and the same procedures, except that S may use both hands to raise canopy (while holding safety strut in one hand--see Figure B-12). Procedure and Score: (Same as for V19, except use both hands.)

Pull/Push Tasks

Tasks V21 - V26 use various grip point devices attached to the cable of the Dynamic Pull Machine (DPM). The DPM comprises six components (See Component numbers on Figure B-13): (1) Sperry-Rand magnetic particle brake (MB), (2) power pack for MB brake with adjustable brake resistance dial, (3) a plastic-coated cable wound nonoverlapping around a reel and shaft attached to the MB brake, (4) a retract motor, (5) a quick-snap hook on the end of the cable used to connect a variety of (6) grip point devices. The pull or push force for a particular criterion task is converted to brake resistance by attaching a Chatillon dynamometer to the cable, then rotating the dial on the power pack until the specified force is set (See Figure B-14).

V21. Rope Pull, Initiating Force (RP160). Equipment: Use a 25 foot length of rope attached to the DPM (See Figure B-15) set at 160 pounds force resistance. (The actual task is a 2-person pull on the rope to position a "pelican hook" under an anchor chain, total initiating force, 320 pounds.) Procedure: S rapidly pulls rope 10 feet. Score: Record seconds. Assign 120 seconds if incomplete and also record distance (feet) pulled. (See Table B-1 for WKO score).

V22. Rope Pull, Sustaining Force (RP60). Equipment: (Same as for V21, but DPM set at 60 pounds). Procedure: S pulls rope 20 feet. Score: (Same as for V21, but 30 seconds for incomplete.)

V23. Cart Pull, Initiating Force (CRT75). Equipment: Use handle bar grip point device attached to DPM (See Figure B-16), set at 75 pounds resistance. (The actual task is a 3-person push/pull to maneuver and position a NR-5C mobile cart total initiating force, 225 pounds. Total weight of cart is 3500 pounds.) Procedure: S pulls handle 30 feet. Score: Record seconds. Assign 50 seconds if incomplete, and also record distance (feet) pulled. (See Table B-1 for WKO score.)

V24. Cart Pull, Sustaining Force (CRT45). Equipment: (Same as for V23, but DPM set at 45 pounds.) Procedure: S pulls handle 100 feet. Score: (Same as V23, but 120 seconds for incomplete.)

V25. Fuel Hose Drag (HS105). Equipment: Use handle bar grip point device (See Figure B-16) attached to DPM set at 105 pounds resistance. (The actual task is a 2-person pull to remove a fuel hose from storage, under the flight deck, and drag it across the non-skid surface of the flight deck to an aircraft.) Procedure: S pulls handle 80 feet. Score: Record seconds. Assign 140 seconds if incomplete and also record distance (feet) pulled. (See Table B-1 for WKO score.)

V26. Power Cable Rig (CB100). Equipment: Use grip point device that simulates a 3-inch diameter, 80 pound section of shore power cable (See Figure B-17). Attach to DPM set at 100 pounds resistance. (The actual task is a lift/pull effort by a 15-person work group spread out along the length of an 85 foot power cable to connect a series of such cables from the pier to the ship, sometimes extending across other ships in a nest that are moored closer to the pier. See Figure B-18.) Procedure: Lift and pull the cable device 40 feet. Score: Record seconds. Assign 120 seconds if incomplete, and also record distance (feet) pulled. (See Table B-1 for WKO score.)

V27. Bolt Torque (BLTRQ). Equipment: Use same device as for V1 (See Figure B-19). (The actual task is a pull effort using a 26 inch torque wrench to tighten/loosen bolts on machinery that is installed in spaces that restrict body movements and arm reach, thereby requiring a pull effort on the wrench with one hand while bracing the other hand on the machinery.) Procedure and Score: (Same as for V1.)

Figure B-1. USAF-designed incremental lift machine (ILM).

Figure B-2. Grip point device for drop tank carry attached to weight bar and carry cart.

Figure B-3. Tow-bar run equipment--nose gear tow bar and simulated cross-deck pendant.

Figure B-4. Grip point devices (3) for fuel probe or acetylene bottle carry attached to weight bar (weights vary).

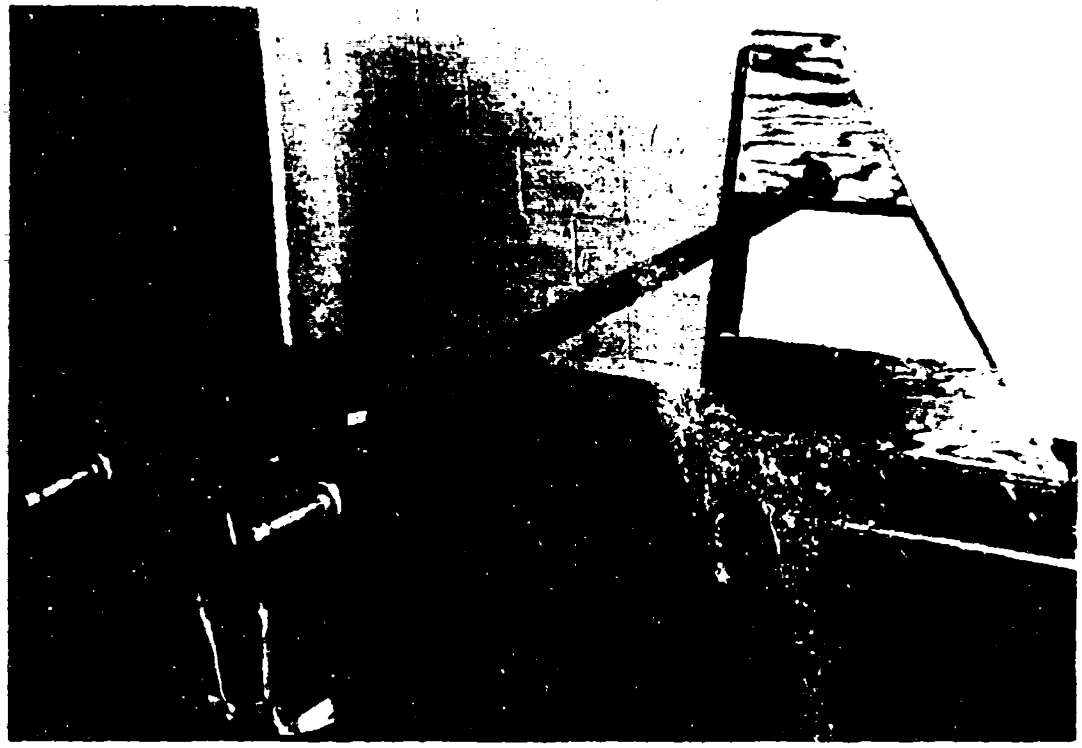


Figure B-5. Grip point device for crucible pour attached to rotatable weight bar, carry cart, and track.

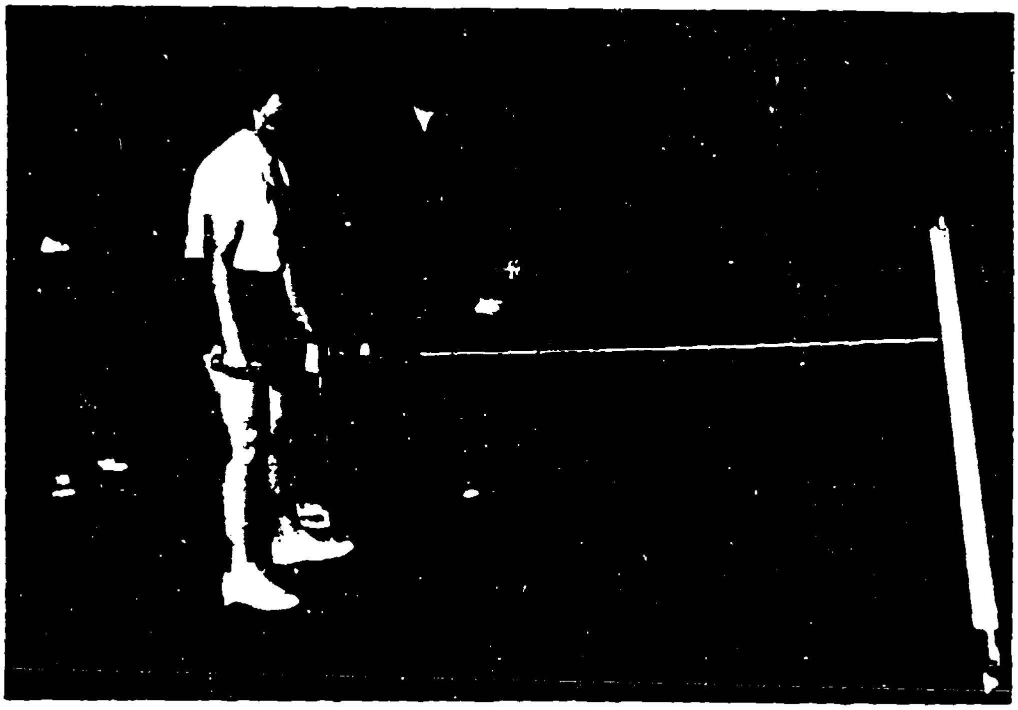


Figure B-6. Grip point devices for crucible pour attached to rotatable weight bar, carry cart, and track.

Figure B-7. Grip point device for equipment carry.

Figure B-8. Grip point device for acetyiene bottle carry up ship's ladder attached to weight bar, carry cart, ladder track, and safety line.

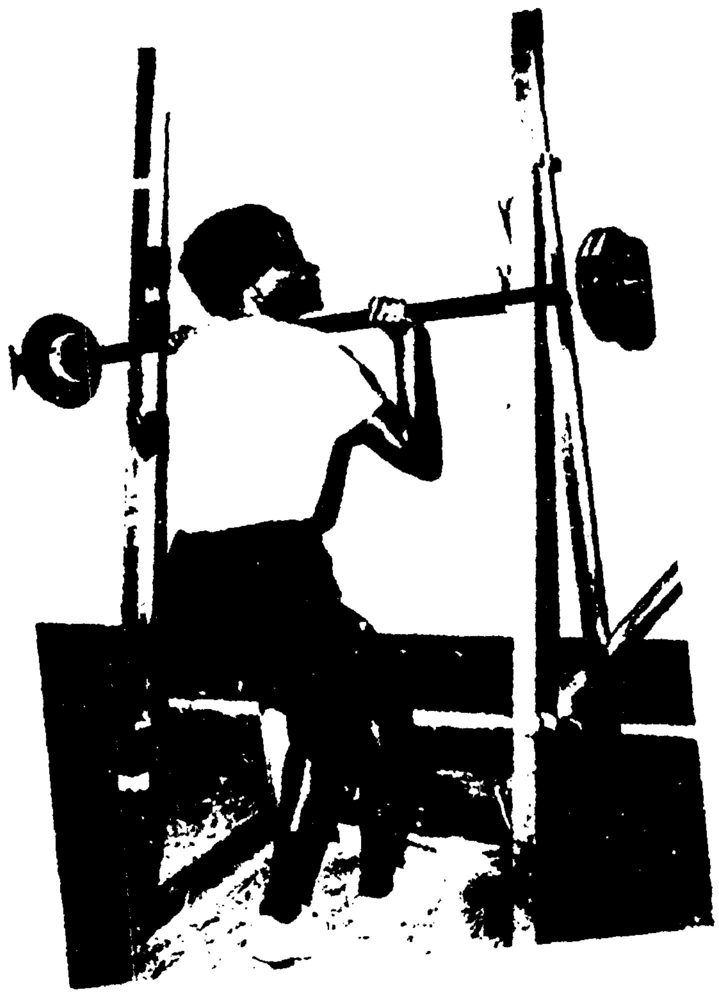


Figure B-9. Bomb loading simulator.


Figure B-10. Canopy raise simulator.

Figure B-11. Canopy raise simulator.

Figure B-12. Canopy raise simulator.

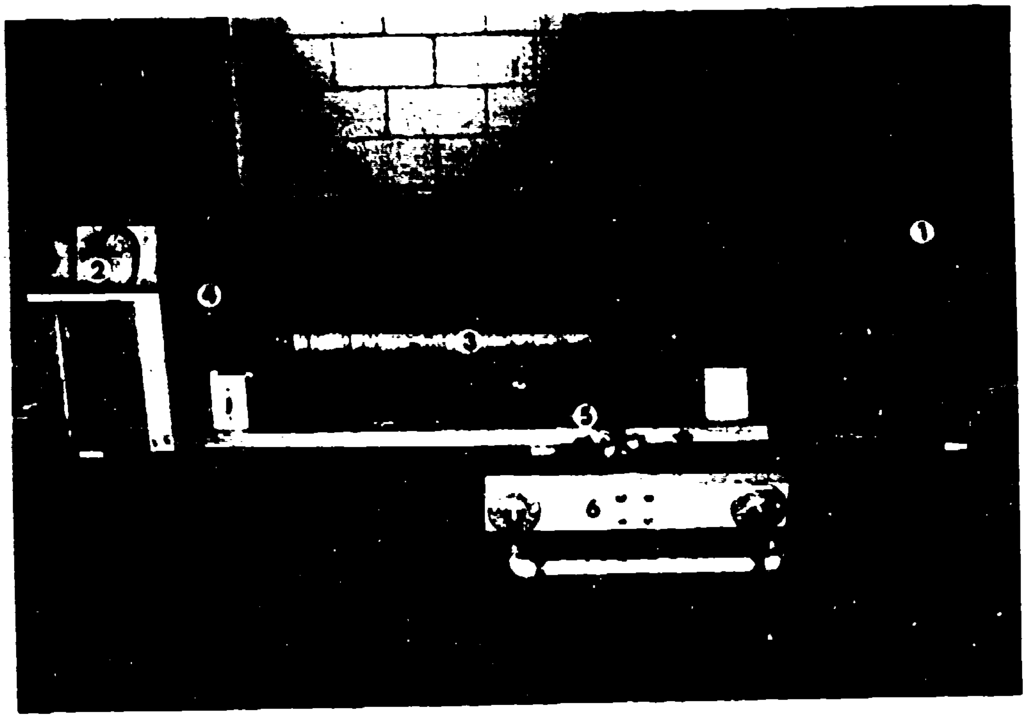


Figure B-13. Dynamic pull machine (DPM) with its six principal components.

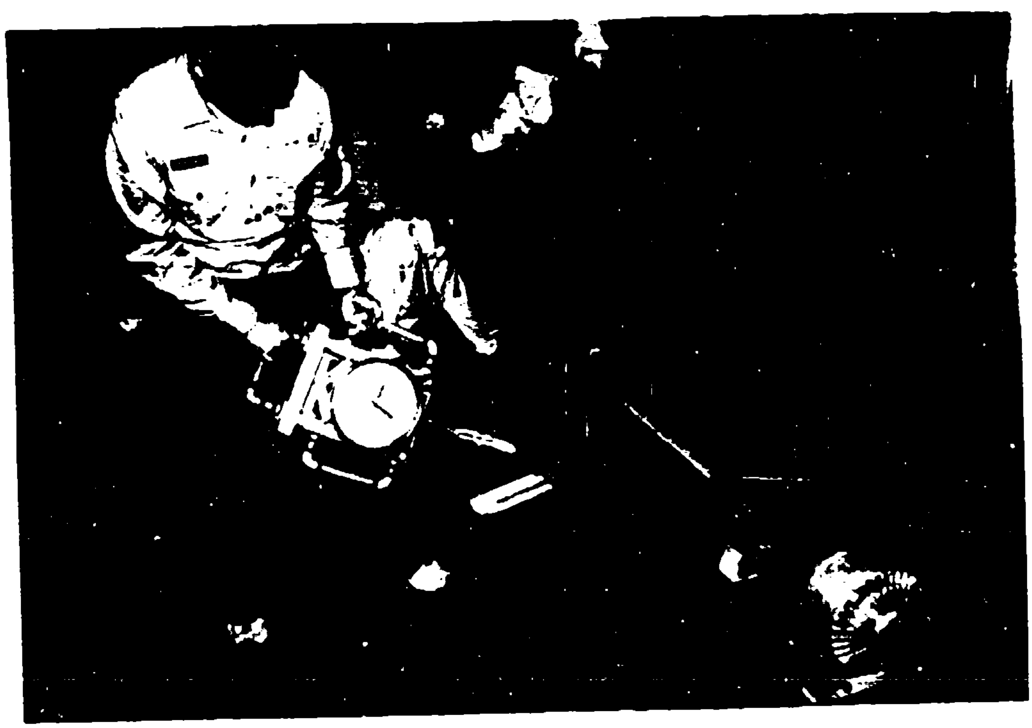


Figure B-14. Setting a specified resistance force (in pounds) on DPM.

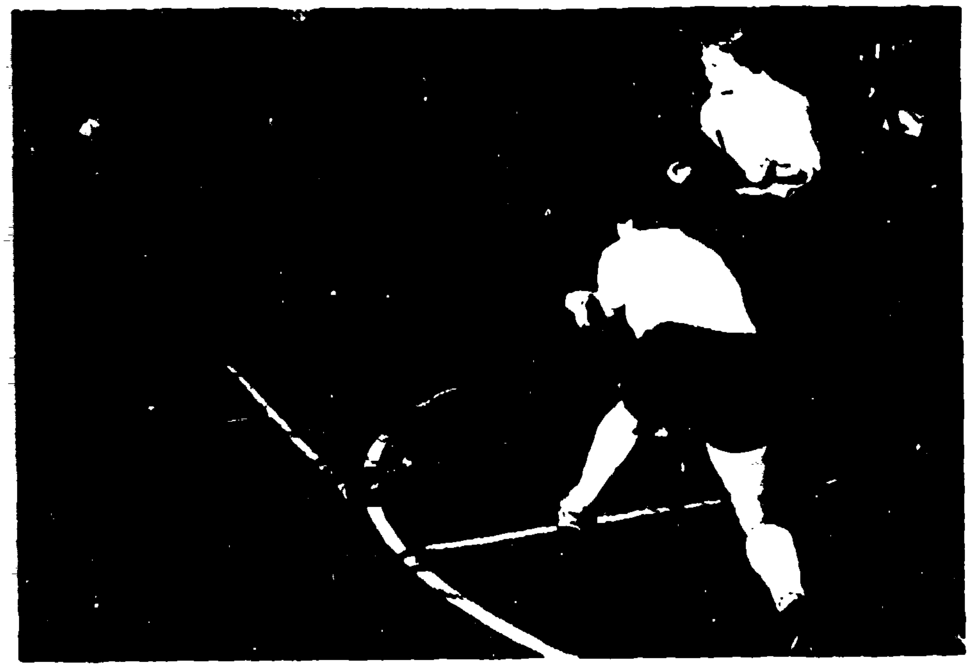


Figure B-15. Grip point device for rope pull attached to DPM.

Figure B-16. Grip point for cart pull and fuel hose drag attached to DPM.

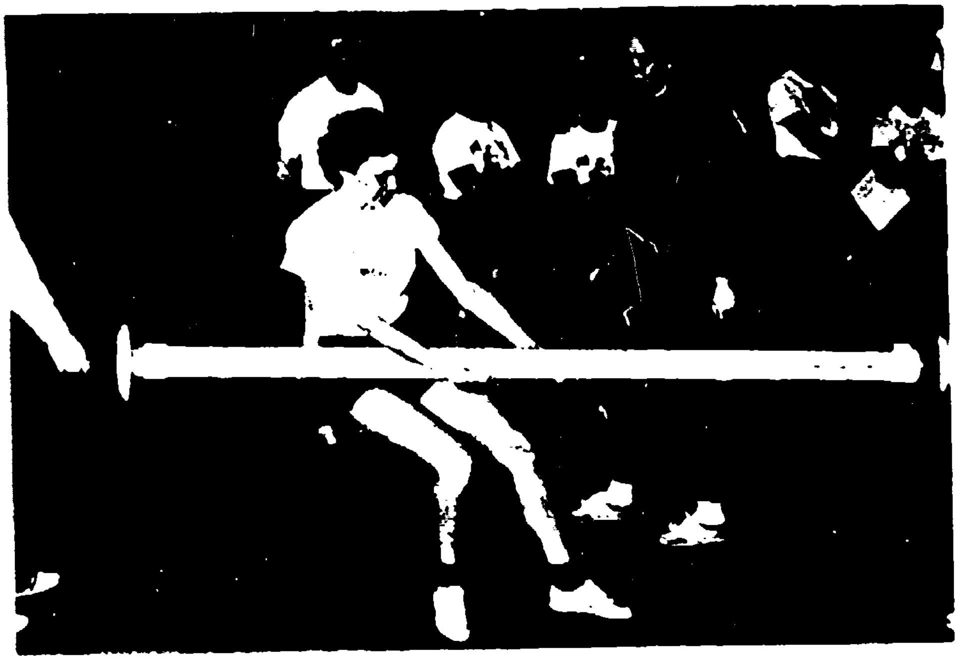


Figure B-17. Grip point device for shore power rig attached to DPM.

Figure B-18. Actual task to rig shore power cable from pier to ship. (Copyright 1984. Used by permission of Union-Tribune Publishing Co.)

Figure B-19. Bolt torque simulator.

Table B-1

Criterion Tests and Performance Standards for Occupation-Specific Tasks

	Task	(Rating)	Abbrev.	Criterion Test: Weight Load(s)	Criterion Test: Force Setting	Criterion Test	Criterion Test: Distance Feet	Criterion Test: Max Sec	TP Std.: Weight	TP Std.: Sec	TP Std.: Work Output (WKO) In Required Distance
10	Drop-tank carry	(AD)	DRPTK	100		fwd bkw	100 100	90 90	100	75 75	Av fwd, bkw dist/sec =1.33
11	Tow-bar run (clear)	(ABH)	TWB-C	62		Clear	300	180		55	$\frac{ft}{sec} x \frac{ft}{300} = 5.45$
12	Tow-bar run (across cable)	(ABH)	TWB-X	62		X-cable	300	240		65	$\frac{ft}{sec} x \frac{ft}{300} = 4.62$
11/12	Tow-bar run (total)	(ABH)	TWBCX	62		Clear+ X-C	600	420		120	Sum = 10.07
13	Fuel probe/acetylene bottle carry	(BM,SHIP)	FP/AC	50,69,88 114,120		fwd bkw	50 50	90 90	BM:120 HT:114	45 45	Av fwd, bkw wt/sec = 2.67(BM), 2.53 (HT)
14	Crucible pour	(ML)	CRUCB	90,130,153,168		Carry Pour	20 20	60 120	153	30 40	Av carry $\frac{wt\ x\ dist}{sec}$ = 87.43
15	5-Gallon can carry	(BM,SHIP)	5GCAN	35,45,60,75,95			170 (incl up 2 ldr, down 2 ldr)	270	60	180	wt/sec = .33
16	Equipment carry (ladder)	(AVIA,SHIP)	EQUIP	70,119			110 (incl up 1 ldr, down 1 ldr)	150	70	95	$\frac{wt\ x\ dist}{sec}$ = .74
17	Acetylene bottle carry (ladder)	(HT)	ACETB	88,106,133,150			7 steps	45	133	25	$\frac{wt\ (n\ step)}{sec\ (7)}$ = 5.32
18	MK82 bomb load	(AO)	BOMBL	30,50,60,90 120,140,160,180					140		wt = 140
19	Canopy raise (1-arm)	(AME)	CNPY1	22,32,54,65 76,87,98					54		wt = 54
20	Canopy raise (2-arm)	(AME)	CNPY2	22,32,54,65 76,87,98					65		wt = 65
21	Rope pull (initiating 160 pounds)	(BM)	RP160		160		10	120		60	dist/sec = .17
22	Rope pull (sustaining 60 pounds)	(BM)	RP60		60		20	30		30	dist/sec = .67
23	Cart pull (initiating 75 pounds)	(AS)	CRT75		75		30	50		25	dist/sec = 1.20
24	Cart pull (sustaining 45 pounds)	(AS)	CRT45		45		100	120		80	dist/sec = 1.25
25	Fuel hose drag (105 pounds)	(ABF)	HS105		105		80	140		80	dist/sec = 1.00
26	Power cable rig (80/100 pounds)	(EM)	CB100		100		40	120		75	dist/sec = .53
27	Bolt torque	(ABE)	BLTRQ					90			force = 90

Note. Those standards for which the minimum weight carried was more important than the speed at which any (especially lighter) weight was carried (V13-V17), each performance standard used both a minimum weight and time, thus WTWKO, with WT ranked first, then WKO ranked within WT. For examples, the complete standard for V13 (BM) is 17002.67, and for V17 is 13305.32.

APPENDIX C

SHIPBOARD TASK TESTING PROCEDURES AND PERFORMANCE STANDARDS

SHIPBOARD TASK TESTING PROCEDURES AND PERFORMANCE STANDARDS

Scoring

Time to Perform

All scoring was time in seconds to perform the task. See maximum seconds below that were assigned for incomplete performance of a particular task (exception: minimum seconds for fire hose nozzle task). These maximum times extend well beyond the task performance standard seconds for the applicable routine or operational/emergency condition (see Table C-2).

Adjustment for Varying Tightness of Watertight Door (WTD) Levers

Because of fleet operating schedules, all subjects could not be tested on the same equipment aboard one ship. Thus, scores were adjusted by increasing the times of the subjects who were tested on the less tight (i.e., easier) WTD (see Table C-1). Tightness is average pounds force at the grip point, that is at point where lever or dog wrench is grasped.

Administration (See Table C-2 for task performance standards)

Movement through WTD and Scuttles

1. Single-lever WTD, normal tightness: Unlock and open, step through, close and lock; then unlock and open, step through, close and lock (total of 4 lever actuations). Assign 50 seconds for incomplete performance.

2. Single-lever WTD, tight: Unlock and open, step through, close and lock; then unlock and open, step through, close and lock (total of 4 lever actuations). Assign 100 seconds for incomplete performance.

3. 8-dog WTD, normal tightness: Use standard dog wrench/pipe. Specify sequence of opening/closing dogs (same as above, total of 32 lever actuations). Assign 300 seconds for incomplete performance.

4. 10-dog WTD, tight: (Same procedures as for 8-dog, but total of 40 lever actuations). Assign 720 seconds for incomplete performance.

5. Scuttle: Climb vertical ladder (one deck), unlock and raise scuttle, climb through to above deck, reenter scuttle, lower and lock, descend to deck. Assign 120 seconds for incomplete performance.

Extricate Injured

1. Stretcher Carry (2-person), level using Stokes stretcher (25 pounds) and manikin (166 pounds): Pick up stretcher from deck, carry 50 feet through passageway with 2 open WTDs with 10 inch high base of WTD; then reverse direction of carry, returning through same passageway to starting point and lower stretcher. Stretcher must be handled gently with no bumping/jarring. Assign 100 seconds for incomplete performance.

2. Stretcher carry (2-person), up/down inclined ladder (using same equipment as above): Starting with stretcher on deck in passageway adjacent to base of ladder, pick up

and maneuver onto ladder, carry up one deck; after brief rest, carry back down one deck to starting point and lower to deck. Scored as sum of carry up plus carry down times, excluding rest period on upper deck. Assign 300 seconds for incomplete carry up, and 200 seconds for incomplete carry down.

3. Shoulder drag (1-person), level (using 166 pounds manikin): Grasping prone victim on deck under shoulders, drag 40 feet level, including over base of one open WTD; then gently lower victim's head to deck. Assign 90 seconds for incomplete performance.

Fire and Flooding Emergencies

1. Oscillate 1-1/2 inch fire hose nozzle: Wearing oxygen breathing apparatus (OBA, 14 pound) and foul weather gear (FWG), the nozzle person (with another 3 to 5 persons as hose handlers) moves lever from "off" to "fog", performs 10 rapid vertical sweeps (raise/lower nozzle through arc of 3 feet in 10 seconds, i.e., one second per raise/lower cycle), advances 10 feet and commences horizontal sweep (150 degree arc, 40 right/left sweeps per minute). When subject can no longer maintain sweep, or at end of 300 seconds, whichever occurs first, step back and move lever to "off." Rotate to last hose handler position. First hose handler steps up to nozzle position. Scored as maximum of 300 seconds for completed, acceptable performance.

2. Oscillate 2-1/2 inch fire hose nozzle: With one person at nozzle position and 3 to 5 persons as hose handlers, the nozzle subject performs horizontal sweeps (90 degree arc giving effective 180 degree arc of fog, maintaining 40 right/left sweeps per minute). When subject can no longer maintain sweep (or after a maximum 90 seconds, whichever occurs first), nozzle subject rotates to last hose handler position and first hose handler moves up to nozzle position. Proceed through 2 complete rotations of all subjects. Scored as seconds for sum of first and second performance at nozzle position (maximum of 90 for completed, acceptable performance for each period at nozzle position).

3. Carry emergency suction hose (10 foot length, 43 pounds): Carry hose down inclined ladders, down 2 deck levels and then level for 75 feet and place on deck. After one or two minute rest period, pick up hose and carry, via same route, back up 2 deck levels. Scored as seconds, excluding resting time, with a maximum of 120 seconds for down-ladder and level carry and 120 seconds for level and up-ladder carry for incomplete performance.

4. Carry (2-person) emergency P250 pump (147 pounds): Carry pump down inclined ladders for 2 deck levels, across 75 foot level distance, up inclined ladder for 1/2 deck level. After brief rest, carry back up to starting location via same route. Scored as seconds, excluding rest period with a maximum of 300 seconds for down-ladder route, and 200 seconds for up-ladder route for incomplete performance.

5. Start P250 pump: Pull the full length of the lanyard 8 times, using both hands, as rapidly as possible. Scored as seconds to complete 8 pulls or a maximum of 48 seconds for incomplete performance.

Analysis

Criterion tests and performance standards for these shipboard tasks are presented in Table C-2. Validity coefficients for men and women separately are presented in Tables C-3 and C-4. Table C-5 presents validity coefficients obtained when the male and female samples are combined. Table C-6 presents an application of an impact analysis procedure developed for these tasks.

Table C-1

Watertight Door Performance Weight Adjustments

Watertight Door	Ship 1		Ship 2		Ship 3	
	Tightness	Score Adjustment Factor	Tightness	Score Adjustment Factor	Tightness	Score Adjustment Factor
1. Single lever (normal)	99	1.00	82	1.21	68	1.46
2. Single lever (tight)	150	1.03	155	1.00	99	1.57
3. 8-dog (normal)	50	1.26	63	1.50	53	1.19
4. 10-dog (tight)	97	1.08	105	1.00	79	1.33

Table C-2

Criterion Tests and Performance Standards for Shipboard Tasks

Task	Condition[a]	Task Performance Standard (TPStd) in seconds
Movement through watertight door		
Single lever (normal)	Routine	40
	Ops/Emerg	20
Single lever (tight)	Routine	80
	Ops/Emerg	60
8-dog (normal)	Routine	240
	Ops/Emerg	180
Movement through scuttle	Ops/Emerg	90
Stretcher carry		
Level	Ops/Emerg	60
Total up and down	Ops/Emerg	150
Shoulder drag	Ops/Emerg	40
Fire fighting		
1-1/2" nozzle	Ops/Emerg	180
2-1/2" nozzle	Ops/Emerg	60
Hose carry		
Down ladder	Ops/Emerg	40
Total up and down ladder	Routine	120
Emergency pump (P250) carry		
Down ladder	Ops/Emerg	45
Total up and down ladder	Routione	240
Pull start	Ops/Emerg	16

[a] Condition--performance during battle operations or emergencies (Ops/Emerg), or during routine maintenance or upkeep activities.

Table C-3

Correlations Between STB and Shipboard Tasks for Male Subjects

TASK	HT	WT	LBW	PCFAT	ARMPL	ARMLF	PL+LF	ERGOM	HGRP	PSHUP	SITUP	MEAN	SD
	STB												
Watertight Door													
8-dog	19	42	36	51	62	80	77	64	69	-02	15	118.57	32.67
10-dog	27	48	46	38	73	71	80	57	75	12	09	241.32	74.15
Single lever (normal)	-05	31	20	48	16	24	22	25	19	09	-07	12.12	1.91
Single lever (tight)	18	54	50	51	57	64	67	69	57	-06	03	16.02	6.85
Scuttle	11	21	17	30	43	34	44	44	42	-05	-09	36.00	11.08
Stretcher Carry													
Level	29	15	15	13	49	36	52	31	46	-15	-27	30.41	5.49
Up ladder	42	43	43	25	65	59	74	61	73	08	05	45.46	57.32
Down ladder	40	40	40	22	63	61	74	57	73	13	05	37.29	36.09
Total up and down	41	42	42	24	64	60	74	60	73	10	05	82.75	93.50
Shoulder Drag	21	26	14	43	32	20	30	12	53	17	-09	27.45	10.55
Fire Fighting													
1-1/2 inch nozzle	-37	-37	-31	-33	19	08	19	-03	-23	37	66	295.91	19.19
2-1/2 inch nozzle	26	20	22	16	69	53	70	70	53	12	16	132.94	41.10
Hose Carry													
Down	02	29	27	25	47	42	50	45	45	-08	16	32.30	8.60
Up	07	40	31	46	47	47	52	23	52	-11	-22	33.07	8.56
Emergency Pump (P250) Carry													
Down	-34	-00	-10	21	32	05	23	46	08	25	19	63.86	70.23
Up	-20	05	-00	15	48	29	44	55	31	26	16	59.54	59.13
Total up and down	-29	02	-06	19	41	17	34	52	19	27	19	123.39	124.23
Pull start	23	34	32	30	68	55	71	67	71	19	13	8.35	3.04
Mean	68.21	164.64	60.77	.1792	127.06	101.53	228.59	52.03	56.44	27.37	28.86		
Standard Deviation	2.84	30.33	8.66	.0532	29.11	21.46	45.36	14.25	7.62	11.09	8.50		

Note. Decimal points of correlations have been omitted. Sample personnel from SIMA, N = 24. r = .28-.39 significant at .10 level, r = .40-.45 at .05, r = .46+ at .01.

Table C-4

Correlations Between STB and Shipboard Tasks for Female Subjects

TASK	STB												
	HT	WT	LBW	PCFAT	ARMPL	ARMLF	PL+LF	ERGOM	HGRP	PSHUP	SITUP	MEAN	SD
Watertight Door													
8-dog	49	45	53	10	65	61	71	71	55	21	-16	169.00	63.52
10-dog	13	23	31	01	56	38	58	49	34	18	-03	368.26	166.21
Single level (normal)	44	24	40	-07	23	34	29	34	35	20	36	18.27	3.78
Single level (tight)	40	29	39	-02	59	61	66	65	35	12	-10	46.83	34.04
Scuttle	35	30	39	00	27	36	33	46	62	18	35	57.90	17.85
Stretcher Carry													
Level	55	46	56	07	71	66	77	73	65	21	-02	50.19	17.59
Up ladder	37	18	24	-01	79	55	80	57	41	04	-17	193.62	105.84
Down ladder	36	17	24	-01	78	58	81	59	44	08	-09	127.43	71.80
Total up and down	37	18	24	-01	79	56	81	58	42	05	-14	321.05	177.30
Shoulder Drag	41	-02	08	-19	46	44	53	39	51	10	48	59.14	26.32
Fire Fighting													
1-1/2 inch nozzle	77	55	70	06	39	63	60	61	40	14	-03	279.77	55.21
2-1/2 inch nozzle	45	30	37	04	74	68	81	66	55	18	01	125.62	47.39
Hose Carry													
Down	57	36	50	-06	63	62	70	69	51	08	-12	51.48	25.22
Up	58	35	48	-03	59	47	62	52	45	04	03	55.81	24.46
Emergency Pump (P250) Carry													
Down	44	44	54	05	79	52	79	66	58	14	10	144.43	89.86
Up	35	41	47	14	79	51	79	57	48	12	07	110.52	63.34
Total up and down	41	44	52	09	80	52	80	63	55	13	09	254.95	150.80
Pull start	65	46	61	-02	59	62	67	62	40	-08	06	20.27	8.52
Mean	64.25	136.68	44.67	.2789	92.32	68.17	160.48	34.93	40.91	7.07	27.47		
Standard Deviation	3.62	14.42	3.80	.0258	22.90	11.41	29.98	7.13	4.86	7.53	7.57		

Note. Decimal points of correlations have been omitted. Sample personnel from SIMA, N = 21. r = .29-.49 significant at .10 level, r = .42-.48 at .05, r = .49+ at .01.

Table C-5

Correlations Between Strength Test Battery (STB) and Shipboard Tasks for Combined Male and Female Samples

Task	STB											Mean	SD
	HT	WT	LBW	PCFAT	ARMPL	ARMLF	PL+LF	ERGOM	HGRP	PSHUP	SITUP		
Water tight door													
8-dog	52	52	55	-18	67	67	72	67	64	38	04	143.79	56.04
10-dog	34	46	52	-23	66	59	68	58	61	41	04	296.14	136.67
Single lever (normal)	47	48	63	-48	46	60	57	55	64	59	10	14.60	4.12
Single lever (tight)	49	45	57	-33	61	61	67	62	59	42	-05	29.50	27.84
Scuttle	44	43	55	-35	53	58	60	60	69	45	09	44.85	17.75
Stretcher carry													
Level	59	47	60	-44	71	67	76	63	71	51	-03	39.06	15.70
Up ladder	54	50	64	-46	82	74	85	71	76	54	-04	114.60	111.34
Down ladder	52	48	61	-45	81	72	84	69	74	53	-01	79.36	71.36
Total of up and down	53	49	63	-46	82	73	85	71	75	53	-03	193.96	182.44
Shoulder drag	51	36	51	-41	55	56	60	49	69	52	17	40.25	24.16
Fire fighting													
1-1/2" nozzle	48	12	21	-23	29	32	33	27	22	28	19	289.91	36.96
2-1/2" nozzle	36	23	22	02	65	45	61	57	41	14	10	129.98	43.44
Hose carry													
Down	52	40	51	-32	60	55	63	58	57	35	-01	40.20	19.70
Up	55	45	56	-33	61	57	64	51	62	39	-05	42.43	20.24
Emergency pump (P250) carry													
Down	26	31	38	-25	62	41	58	62	48	48	13	98.39	88.10
Up	23	30	36	-20	67	48	64	62	51	44	11	81.39	65.49
Total of up and down	25	31	38	-23	66	45	62	64	51	48	12	179.78	149.99
Pull start	62	50	67	-47	67	69	74	68	72	52	06	13.17	8.29
Mean	66.38	151.70	53.45	15.51	111.27	86.36	197.63	44.26	49.38	18.00	78.22		
SD	3.77	27.92	10.59	5.22	31.53	24.21	51.73	14.34	10.13	13.97	8.05		

Note. Decimal points of correlations have been omitted. Sample were men and women from Shore Intermediate Maintenance Activity (SIMA), N = 45. r = .29-.36 significant at .05 level, .37+ at .01.

Table C-6

Application of Impact Analysis Procedure for Shipboard Tasks

Task	Condition	Sex	Performance Sample (SIMA)[b] % Below TPStd[a]	Performance Sample (SIMA)[b] STB Cut-score (PL+LF) that cuts off that Percentage	% of Entry Sample Below Comparrable PL+LF Cut-Score[c] Training Start	% of Entry Sample Below Comparrable PL+LF Cut-Score[c] Training End
Watertight door						
Single lever (normal)	Routine	M	0	(uncorr)	---	---
		W	0	---	---	---
	Ops/Emerg	M	0	(uncorr)	---	---
		W	29	143	59	34
Single lever (tight)	Routine	M	0	---	---	---
		W	24	136	46	23
	Ops/Emerg	M	0	---	---	---
		W	29	143	59	34
8-dog	Routine	M	0	---	---	---
		W	19	132	37	17
	Ops/Emerg	M	5	139	0	0
		W	24	136	46	23
Scuttle	Ops/Emerg	M	0	---	---	---
		W	5	111	9	2
Stretcher carry						
Level	Ops/Emerg	M	0	---	---	---
		W	24	136	46	23
Total up and down	Ops/Emerg	M	4	138	0	0
		W	81	180	94	88
Shoulder drag	Ops/Emerg	M	10	147	0	0
		W	57	183	83	65
Fire fighting						
1-1/2" nozzle	Ops/Emerg	M	0	(uncorr)	---	---
		W	8	112	10	2
2-1/2" nozzle	Ops/Emerg	M	6	142	0	0
		W	9	119	17	5
Hose carry						
Down	Ops/Emerg	M	10	148	0	0
		W	53	162	82	63
Total up and down	Routine	M	0	---	---	---
		W	24	136	46	23
Emergency pump (P250) carry						
Down	Ops/Emerg	M	36	(uncorr)	---	---
		W	90	203	99	99
Total up and down	Routine	M	14	177	1	0
		W	38	149	68	46
Pull start	Ops/Emerg	M	6	142	0	0
		W	71	170	89	75

M—Men, W—Women

[a] The cut-score for arm-pull plus arm-lift (PL+LF) that identifies the percentages of the TPT sample that performed below the TPStd (see Table C-2 for standards). If the predictor (PL+LF) was not valid at the .10 significance level ($r < .28$ for men, $r < .29$ for women; see Tables C-3 and C-4), the cut-score is not displayed ("uncorr"). Also, if the cut-score is outside the range of scores for the subgroup (i.e., 0% or 100% of subgroup below TPStd), the cut-score is not displayed (---), nor is the application to an entry sample.

[b] Sample were personnel from shore intermediate maintenance activity (SIMA) N = 24 men and N = 21 women.

[c] Entry sample were recruits tested at start of training N = 350 men and N = 269 women and end of training N = 493 men and N = 243 women.

APPENDIX D

DEVELOPMENT OF DATA BASES OF MUSCULARLY DEMANDING TASKS

DEVELOPMENT OF DATA BASES OF MUSCULARLY DEMANDING TASKS

Documentation of Muscularly Demanding Tasks

Data analysts (college graduate students) were briefed on the following procedures.

1. To identify tasks with the greatest muscular demands (GMD).

2. Within the total data set, to retrieve certain types of tasks by BBE type, unit, rating, force, restricted space, duration, etc., or combinations thereof. For example, a derived variable--weighted sum (WTSUM)--can be created by summing the six products of the numerical value of effort code (see p. A-17, item 4) times the percent value of the workgroup performing at each effort code. The most muscularly demanding task on board a submarine, for example, is removing a davit (WTSUM = 300, see Table 2).

Criteria for Use of Data

The following criteria were used for selection of GMD tasks to be accepted or rejected to enter the data base:

All Formats

1. Include and record the task if the object (item 1) is an identifiable, single object that a research team member could be directed to by an incumbent.

2. Reduce the description to 50 spaces in a sequence of object, semicolon, type action (verb), or site to which the object is taken.

Examples:
HT Rating: Welding leads; carry shop to job.
MM Rating: Main steam valve; open/close.

3. Include the task if hands-on force in pounds is amenable to objective measurement (force, distance, duration).

Rating/NEC-Specific Detailed Format

Include the task if: the force for BBE 1, 2, 5, 6, or 8 (item 17) is greater than or equal to 30 pounds or the subjective physical demand (item 3) is code 2 or greater; BBE equals 3; the subjective physical demand for BBE 4, 7, 9, 10, or 11 is greater than or equal to code 2. Otherwise, do not enter the task in the data base.

Rating/NEC-Specific Brief Format

For all BBEs, select and record the task if force is greater than or equal to 30 pounds.

Example:
AMH Rating (Table 1): handle (hydraulic); jack aircraft

Unit Command Detailed Format

For BBE (item 17) 1, 2, 5, 6, or 8 select the task if force (item 3B) is 30 pounds or more, or if percent of workgroup performing (item 4) code 3, 4, or 5 is greater than 0 percent, or code 2 is greater than 20 percent.

Example:
Amphibious ship (Table D-2): Shore power cables; rig.

Unit Command Brief Format

For BBE (item II) 1, 2, 5, 6, or 8, select the task if force (item III) is 30 pounds or more. For BBE 4, 7, 10, or 11, select the task if force is 2 pounds or more and duration (item VI) is 60 minutes or more. For BBE 9, select the task if force is 10 pounds or more.

APPENDIX E

INTERCORRELATIONS FOR STB AND OCCUPATION-SPECIFIC CRITERION TASKS

Table E-4

Means, Standard Deviations, and Intercorrelations for STR and Occupation-Specific Tasks, Male Sample

Test	Rating	Abbrev	ARMPL 1	ARMLF 2	ERGOM 3	HT 4	WT 5	SITUP 6	LMJRK 7	LMPRS 8	LMELB 9	DRPTK 10	TWB-C 11	TWB-X 12	FP/AC 13	CRUCB 14	5GCAN 15	EQUIP 16	ACETB 17	BOMBL 18	CNPY1 19	CNPY2 20	RP160 21	RP60 22	CRT77 23	CRT65 24	HS101 25	CB100 26	BLTRQ 27
STR																													
1 Arm pull		ARMPL		47	44	42	31	09	11	36	63	39	63	33	37	36	69	33	60	55	48	46	63	21	61	63	65	50	78
2 Arm lift		ARMLF			60	27	46	17	60	30	61	36	46	31	29	29	37	44	56	49	60	35	33	20	33	36	47	32	56
3 Ergometer		ERGOM				36	35	29	33	39	68	40	51	18	37	31	61	68	66	57	30	44	42	27	48	58	37	57	55
4 Height		HT					51	09	36	36	57	23	29	23	29	37	32	36	33	51	27	32	23	03	33	33	32	58	49
5 Weight		WT						12	40	47	41	26	26	26	26	27	42	39	61	47	18	47	46	20	38	60	69	56	68
6 Situp		SITUP							50	05	.02	12	16	55	.03	.07	03	08	13	01	08	05	18	12	05	17	18	05	11
7 R.M. Jerk		LMJRK								43	79	27	36	29	49	51	37	32	65	33	52	42	16	01	33	36	29	64	30
8 R.M. Press		LMPRS									22	29	61	25	61	39	39	37	53	60	32	44	76	08	37	65	55	48	62
9 R.M. Elbow		LMELB										23	22	22	41	41	35	37	66	53	65	43	22	01	66	21	29	37	53
TPT																													
10 Drop tank carry	AO	DRPTK											39	29	43	29	22	36	61	48	21	27	22	36	31	36	48	65	37
11 Tow bar run (clear)	ARM	TWB-C												44	22	28	37	30	47	36	31	31	32	32	39	50	65	39	61
12 Tow bar run (across cable)	ARM	TWB-X													22	10	23	29	46	26	27	26	36	23	30	39	61	63	22
13 Fuel probe/acetylene bottle carry	RM, MT	FP/AC														20	35	37	49	37	28	26	.03	09	30	21	26	38	29
14 Crucible pour	ML	CRUCB															36	18	46	33	62	38	13	10	28	26	23	31	78
15 5 gallon can carry	RM, MP	5GCAN																60	49	17	36	31	12	13	41	37	35	51	65
16 Equipment carry (ladder)	AVIO	EQUIP																	44	47	17	33	75	17	29	38	27	63	38
17 Acetylene bottle carry (ladder)	MT	ACETB																		49	62	63	48	36	32	30	64	63	36
18 MK82 bomb load	AO	BOMBL																			63	32	33	28	32	67	46	37	30
19 Canopy raise (1-arm)	AMF	CNPY1																				70	26	19	37	39	29	65	31
20 Canopy raise (2-arm)	AMF	CNPY2																					55	33	30	32	23	46	29
21 Rope pull (initiating 160 pounds)	RM	RP160																						29	28	36	37	67	65
22 Rope pull (sustaining 60 pounds)	RM	RP60																							20	33	36	23	23
23 Cart pull (initiating 77 pounds)	AS	CRT77																								44	65	31	55
24 Cart pull (sustaining 65 pounds)	AS	CRT65																									55	37	63
25 Fuel hose drag (101 pounds)	ARF	HS101																										65	33
26 Power cable rig (80/100 pounds)	FM	CB100																											49
27 Bolt torque	ARF	BLTRQ																											
Mean			130.31	197.37	66.36	69.79	162.97	39.32	108.72	103.83	81.77	6.30	12.71	9.09	31.78	30.33	30.86	31.13	31.82	112.70	37.18	87.36	1.00	6.96	6.20	10.06	4.79	7.62	165.16
Standard Deviation			29.48	17.66	9.50	2.69	22.71	6.09	21.67	18.57	17.29	1.70	2.30	2.16	29.17	29.06	29.08	29.07	29.37	25.22	11.66	9.07	.60	2.09	1.10	1.61	1.79	1.20	26.77

Note. Decimal points of correlations have been omitted. Sample were recruits in latter half of 7-weeks training, N = 279. Correlation p < .200, r > .10-.17 significant at .01 level.
TE-at-91

Table E-2

Means, Standard Deviations, and Intercorrelations for STB and Occupation-Specific Tasks, Female Sample

Test	Rating	Abbrev.	ARMPL 1	ARMLF 2	ERGOM 3	HT 4	WT 5	SITUP 6	LMJRK 7	LMPRS 8	LMELB 9	DRPTK 10	TWB-C 11	TWB-X 12	FP/AC 13	CRUCB 14	5GCAN 15	EQUIP 16	ACETB 17	BOMBL 18	CHPY1 19	CHPY2 20	RP160 21	RP80 22	CRT73 23	CRT43 24	HS103 25	CB100 26	BLTRQ 27
STB																													
1. Arm pull		ARMPL		52	33	31	42	18	41	43	43	41	36	27	38	33	37	30	40	52	23	33	48	48	60	47	49	39	60
2. Arm lift		ARMLF			33	31	38	11	41	42	42	32	26	25	31	48	33	30	44	28	13	21	39	41	35	47	38	30	46
3. Ergometer		ERGOM				24	37	13	41	44	39	48	32	27	43	43	43	41	30	42	33	36	34	43	49	44	33	37	49
4. Height		HT					46	-08	30	25	26	24	23	30	36	36	27	28	20	38	19	19	28	44	43	32	36	22	38
5. Weight		WT						-10	46	42	40	24	18	19	30	33	38	38	33	34	31	38	42	46	47	40	41	29	38
6. Situp		SITUP							14	20	23	23	13	13	23	16	24	34	39	12	16	10	22	13	11	19	07	13	23
7. ILM-Jerk		LMJRK								86	61	43	21	26	33	49	31	40	37	33	23	26	42	46	36	40	41	38	46
8. ILM-Press		LMPRS									67	43	21	27	37	49	32	47	60	37	28	29	40	43	55	42	44	39	37
9. ILM-Elbow		LMELB										58	13	17	36	40	42	44	31	36	28	39	39	46	46	43	33	43	32
TPT																													
10. Drop-tank carry	AD	DRPTK											34	23	34	37	47	43	31	43	29	43	36	41	41	43	50	27	38
11. Tow-bar run (chair)	ABM	TWB-C												63	38	41	30	36	31	23	03	02	33	36	39	31	37	29	29
12. Tow-bar run (across cable)	ABM	TWB-X													37	31	17	31	30	29	-04	01	20	74	29	27	52	21	23
13. Fuel probe/acetylene bottle carry	BM, HT	FP/AC														34	33	48	40	43	23	31	29	37	33	40	30	32	47
14. Crucible pour	ML	CRUCB															39	42	49	44	29	28	31	34	33	36	78	42	31
15. 5-gallon can carry	BM, Ship	5GCAN																60	30	36	28	30	30	48	52	44	33	33	40
16. Equipment carry (ladder)	Avia., Ship	EQUIP																	50	31	33	30	42	47	49	50	59	27	43
17. Acetylene bottle carry (ladder)	HT	ACETB																		60	33	37	31	36	30	44	37	88	30
18. MK82 bomb load	AO	BOMBL																			70	41	22	47	47	52	52	75	45
19. Canopy raise (1-arm)	AME	CHPY1																				65	25	33	26	52	22	19	37
20. Canopy raise (2-arm)	AME	CHPY2																					75	33	70	55	27	33	43
21. Rope pull (sustaining 160 pounds)	BM	RP160																						47	41	57	36	62	44
22. Rope pull (sustaining 80 pounds)	BM	RP80																							47	51	61	36	48
23. Cart pull (sustaining 73 pounds)	AS	CRT73																								51	61	47	49
24. Cart pull (sustaining 43 pounds)	AS	CRT43																									63	43	49
25. Fuel hose drag (103 pounds)	ABF	HS103																										44	37
26. Power cable rig (200/100 pounds)	EM	CB100																											63
27. Bolt torque	AME	BLTRQ																											
Mean			80.85	63.31	30.36	65.09	132.20	30.26	58.47	53.33	67.68	2.70	6.67	3.01	30.30	30.81	30.02	33.83	35.86	66.30	30.30	66.06	.12	3.71	2.26	1.36	.61	.30	88.55
Standard Deviation			16.72	12.09	11.97	2.46	16.00	6.70	11.01	9.67	7.90	2.02	1.96	2.03	20.96	29.02	29.30	26.83	25.09	15.12	7.30	13.01	.15	1.00	.89	1.09	.32	.30	17.53

Note. Decimal points of correlations have been omitted. Sample were recruits in latter half of 7-weeks training, N = 279. Correlation ns varied 101-238 (except V14 = 73, V17 = 77). For n = 150, r = .16-.20 significant at .05 level, .21+ at .01.

APPENDIX F

SCATTERPLOTS OF CRITERION AND STB SCORES

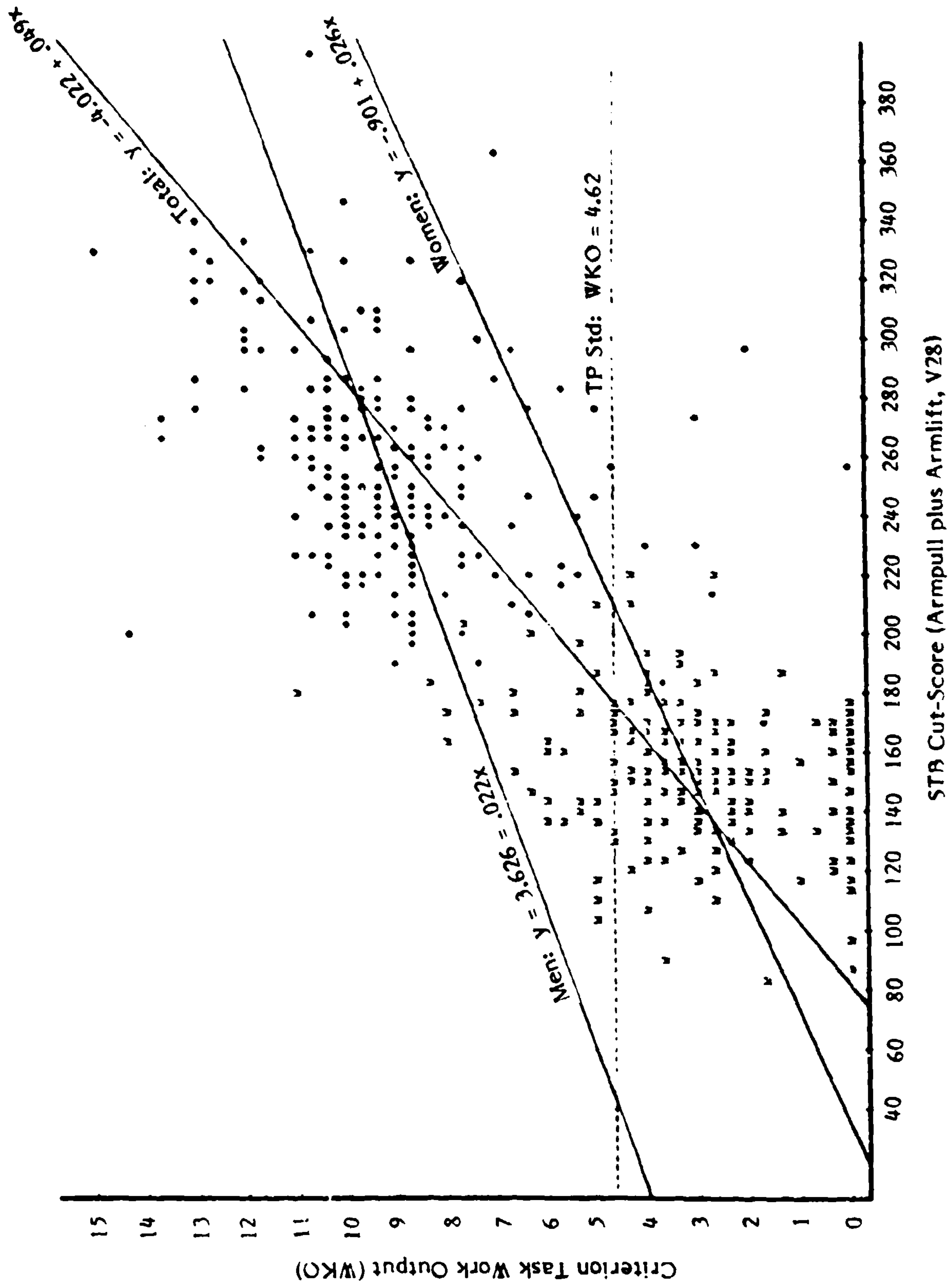


Figure F-1. Scatterplot of criterion and STB scores for a carry task (variable 12, w--women, *--men).

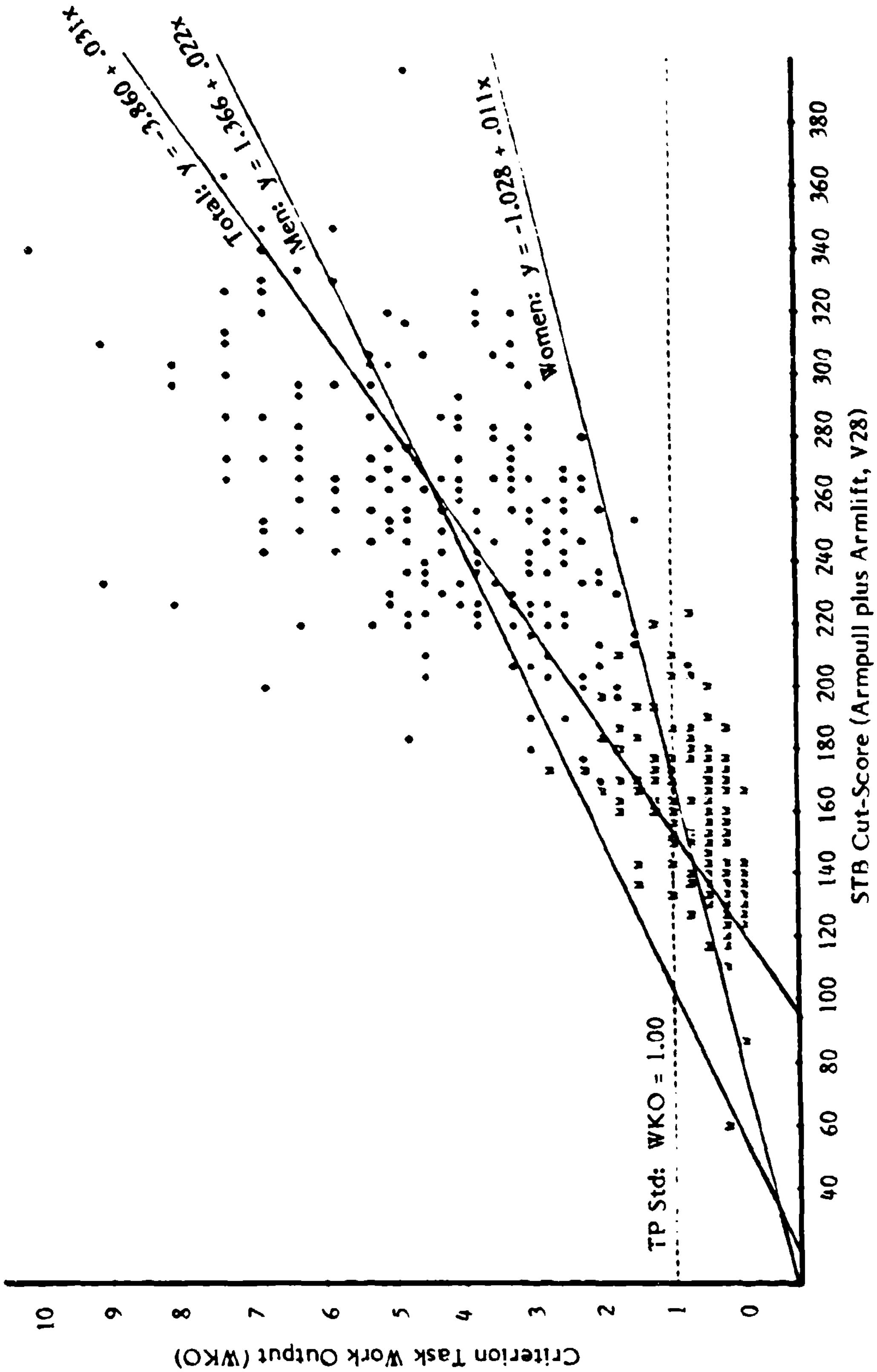


Figure F-2. Scatterplot of criterion and STB scores for a pull task (variable 25, w--women, *--men).

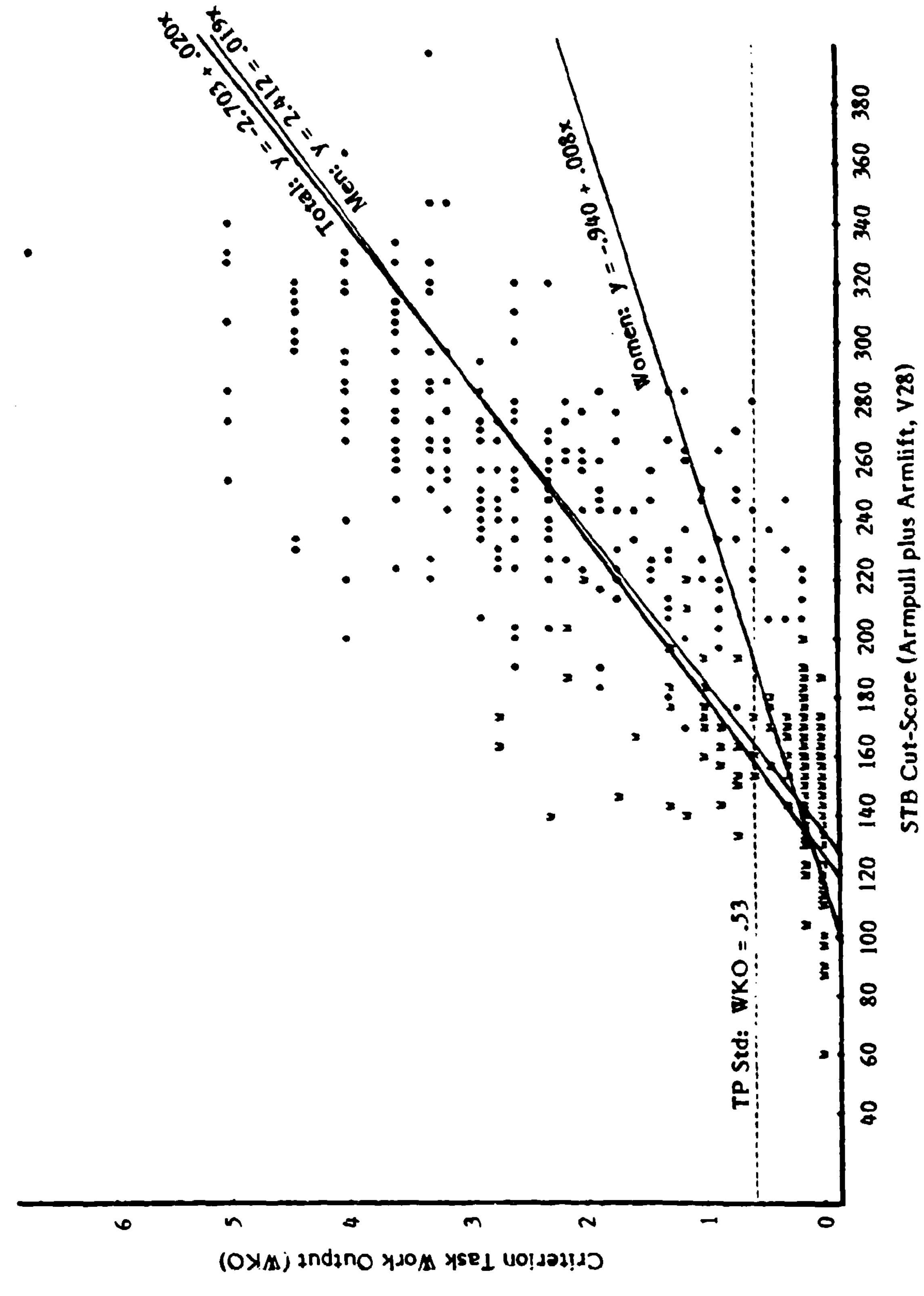


Figure F-3. Scatterplot of criterion and STB scores for a pull task (variable 26, w--women, *—men).