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WEIGHT LIFT CAPABILITIES OF AIR FORCE BASIC TRAINEES

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NOTICES

TECHNICAL REVIEW AND APPROVAL

AFAMRL-TR-83-0001

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 169-3.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

CHARLES BATES, JR.
Chief, Human Engineering Division
Air Force Aerospace Medical Research Laboratory

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To establish physical strength and endurance criteria for assigning personnel to jobs with a heavy physical demand, weight lifting and holding tests were performed on Air Force basic trainees. Maximum weight lift capability was measured on 1066 male and 605 female basic trainees at Lackland Air Force Base. In the Incremental Weight Lift Test, subjects raised the handles of a weight lift machine to a height of 6 feet or more above the floor. The initial weight of 40 pounds was increased by 10 pound increments until the subjects were unable

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to raise the weight to 6 feet. Maximum weight lift capability to elbow height was then measured as a continuation of this Incremental Weight Lift Test. The male basic trainees averaged 114.1 pounds on the Incremental Lift to 6 feet (S.D. = 23.18), while the female basic trainees averaged 56.9 pounds to 6 feet (S.D. = 11.75). The male basic trainees averaged 129.1 pounds (S.D. = 24.60) to elbow height, while the females averaged 67.7 pounds (S.D. = 13.91).

An endurance test measured the duration of holding a 70 pound weight at elbow height. Maximum weight holding endurance was measured on 1066 male and 573 female basic trainees. Male basic trainees held the weight an average of 53.3 seconds (S.D. = 22.11), while the females averaged 10.3 seconds (S.D. = 10.5).

In comparing the body size distributions of these 2132 male and 1178 female basic trainees with previous anthropometric surveys from 1965 and 1968, it was found that there was a significant increase in stature and weight for both males and females.

cont

These and other tests by the Air Force demonstrates a safe methodology for performing weight lift testing. Weight lift testing is valuable as a personnel screening and assignment criterion because it is highly correlated with the types of dynamic lifting in manual materials handling activities.

PREFACE

This report was prepared under Project 7184, Task 08, Work Unit 31 titled Human Physical Capabilities for Air Force Jobs.

The authors wish to acknowledge the contributions of other individuals, without whose of skill and effort this research project could not have been accomplished.

Mr. Nilss M. Aume of AFAMRL/HEG contributed to the design of the study, to the preparation of instructions and forms, and was primarily responsible for the design of the weight lifting machine used in the Incremental Weight Lift Test.

Col R.L. Baker and his staff at the 3700th PRG, Lackland AFB were responsible for reorganizing the basic training schedule so that 4,600 basic trainees were directed to the test facility without fail and on time.

SSgt Travino and Sgt Standridge of WHMC/SGK performed the prescreening of the medical records of potential test subjects.

Sgt John R. Ramirez, Jr. of the 3731st PPS and SSgt Gregory Krewet of the 3700th ABG performed the interviews of each potential test subject to determine if they were qualified to serve as subjects.

The weight lift testing was conducted by Sgt James R. Sebren and Sgt Ceia K. Lancaster of the 3723rd BMTS.

Special acknowledgement goes to Sgt John R. Ramirez Jr., who also served as the Test Instructor, answering questions to clarify the test purpose and procedure. Sgt Ramirez had the responsibility of opening the test facility each morning, setting up the equipment and shutting it down at the conclusion of testing. As test Team Leader, he contributed more effort than any other.

The entire complement of Lackland AFB participants worked long and unusual schedules, including week-ends, to accomplish this data collection. All had regular full time jobs in addition to the substantial effort of this project.

Special appreciation is due the 3300 anonymous Air Force men and women who bent their backs as test subjects in this study. Without individual recognition or reward, their voluntary participation made this study possible.

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INTRODUCTION

The U.S. Air Force, as an employer, has a multidisciplinary job base which is more diverse than any single civilian industry. Mechanics, fire-fighters, band leaders, plumbers, and even seaman can all be found among the 226 enlisted jobs known as Air Force Specialty Codes (AFSCs).

A large number of these jobs encompass tasks which make heavy physical demands upon the men and women assigned to them — demands which, in many cases, are beyond the capabilities of some individuals. Although physical aptitude criteria have played some role in the job-match process, tests such as the current Factor X Test have not been sufficiently rigorous or discriminating to assure successful matching of personnel to a number of physically demanding jobs.

The Air Force is now engaged in a comprehensive study aimed at the development of new strength testing programs. The research presented in this report is only part of the comprehensive program. The objectives of this study are to measure the maximum weight lift capability, weight holding capability, and body size variability of Air Force Basic Trainees to aid in the development of criteria for assigning personnel to jobs with a heavy physical demand.

Two very important gains can be realized by physical aptitude screening: first, readiness to perform the Air Force mission will be enhanced, since workers assigned to heavy demand jobs will have the capability to perform that job, and second, the incidence of manual materials handling accidents and injuries will be reduced because the opportunities for overexertion will be reduced.

Experience demonstrates that lifting injuries, particularly back injuries, are numerous and costly. Statistics from the Liberty Mutual Insurance Company (1972) indicate that 79 percent of manual handling injuries are injuries to the lower back. Although not always serious, lower back injuries affect more than half of the working population at some time in their careers (Rowe, 1971). The cost to U.S. employers is more than one billion dollars per year.

USAF statistics for 1971-1975 list Lifting/Carrying/Lowering as the third largest category of USAF industrial accidents. During 1971-1975, there were 985 such accidents with injuries costing $610,000 and resulting in 8,289 lost days.

There are four traditional approaches to reducing industrial back injuries: (1) careful selection of workers, (2) good training procedures for safe lifting, (3) redefining jobs to fit the worker and (4) preemployment strength testing. In a study of the first three, Snook, et al. (1978) found: (1) no significant reduction in low back injuries in industries where employers used medical histories, medical examination, or low back X-rays in selecting the workers for the job; (2) no significant reduction in lower back injuries among employers who trained their workers to lift properly, and (3) that some two thirds of all injuries may be prevented if the tasks are designed to match the physical capability of 75 percent of the population.

Jobs, of course, are not intentionally designed to exceed the physical capability of a worker and, where this occurs it is often an unavoidable characteristic of the job. In these instances, redesigning the job to fit the worker is desirable but usually not practical or economically feasible. The same result, however, may be achieved by strength screening. By restricting a particular job to an individual with a demonstrated capability to perform it, the occurrence of overexertion may be reduced or eliminated altogether.

BACKGROUND

In early 1972, the Department of Defense began studying the potential role of women in the military and prepared contingency plans to offset shortages of men after the draft ended. With the introduction of the Equal Rights Amendment, The Air Force intensified efforts to open all except combat jobs to women. The plan was to increase the number of women in the Air Force from 11,500 in 1972 to 103,000 by the end of 1986.

In September 1974, the Air Force Director of Personnel Plans asked the Office of the Surgeon to help develop (1) physical standards for occupational specialties with strenuous demands and (2) methods for measuring the physical capabilities of individuals to perform in enlisted job specialties involving heavy work.

In response, representatives of the Office of the Surgeon General recommended measuring physical capacity in four stages:

X-1 can perform maximum heavy duty over prolonged periods (as demonstrated by a lift of 70 lbs to a height of six feet).

X-2 can perform sustained moderate duty over prolonged periods (as demonstrated by a lift of 40 lbs to elbow height).

X-3 can perform sustained light duty over normal work periods (as demonstrated by a lift of 20 lbs to elbow height).

X-4 not acceptable (cannot lift 20 lbs to elbow height).

This series of measurements, later termed the Factor X Test, was administered to enlisted Air Force personnel beginning in March 1976 at Lackland AFB, the Air Force's only basic training facility. As weight lifting equipment was procured and deployed at the 67 MEPS (Military Enlistment Processing Stations), all Air Force and Army recruits were given the test. The procedure for administering the test is Appendix I. After the MEPS (formerly called AFEES for Armed Forces Entrance and Examination Stations) capability for testing individuals was fully implemented, the testing at Lackland AFB was discontinued.

Table 1 shows the distribution of Factor-X ratings for 1978 and points to the major problem with the test procedure.

TABLE 1. FACTOR X WEIGHT LIFT TEST RESULTS FOR AIR FORCE TRAINEES DURING 1978

		Results	
Ratings	Definition	Men	Women
X-1	Lift 70 lbs to 6 feet	98.8%	25.8%
X-2	Lift 40 lbs to elbow height	1.1%	73.6%
X-3	Lift 20 lbs to elbow height	0.1%	0.6%
X-4	Unacceptable	.0%	.0%

All but an insignificant number of people fall into the X-1 and X-2 categories. The criteria applied neither accurately express the wide variations in physical demands among AFSCs nor allow for the necessary discrimination between individuals possessing significant physical strength and those of more limited capability. In fact, a number of high demand AFSCs have been identified by functional managers, supervisors and field surveys as encompassing tasks which require considerably more than the ability to lift 70 pounds to a height of six feet. (See Table 2 for a representative list of such AFSCs).

TABLE 2. EXAMPLES OF JOBS IN THE AIR FORCE WITH HEAVY PHYSICAL DEMAND

AFSC	AFSC Title
115X0	Pararescue and Recovery
316X1	Missile Systems Maintenance
328X3	Electronic Warfare Systems
361X0	Cable and Antenna Installation Mtn.
361X1	Cable Splicing Installation and Mtn.
423X2	Aircraft Egress Systems
431X0	Helicopter Maintenance
431X1	Aircraft Mtn. — Tactical Aircraft
431X2	Aircraft Mtn. — Alft/Bomber Aircraft
443X0	Missile Maintenance
443X1	Missile Pneudraulics Repair
445X1	Missile Liquid Propellant Systems
542X1	Electrical Power Line
545X0	Refrigeration and Air Conditioning
547X0	Heating Systems
551X0	Pavements Maintenance
551X1	Construction Equipment
571X0	Fire Protection
921X0	Survival Training

One further limitation of the current Factor X Test is that each weight is lifted only one time and not held, so there is no representation of endurance.

To improve the classification of enlisted personnel based on strength and stamina criteria, the Air Force Aerospace Medical Research Laboratory, in collaboration with the Air Force Office of Scientific Research, has undertaken a four-phase strength Aptitude Test Battery (SATB) program designed to produce effective strength aptitude tests for assigning personnel to AF jobs requiring heavy work.

In Phase I of the program investigators analyzed the Air Force Specialty Codes (AFSCs) to define and quantify the amount of heavy work required by each job. Because of the large number and distribution of AFSCs, a variety of methods were used to gather job demand data. These include (1) mail-out questionnaire surveys to be sent to more than 16,000 workers, (2) interviews of more than 900 incumbent supervisors at more than 50 bases by field measuring teams and (3) direct measurement of the demand of more than 2,400 tasks.

Phase II of the program involved the development of the tests themselves. First, the demanding tasks identified in Phase I will be categorized to define generic work tasks.

Results to date indicate that the major tasks in which strength is a limited factor are lift/lower and push/pull. Tasks in which endurance is a limiting factor include carrying and holding. Next, special testing will be performed to determine the relationship between the candidate tests and the job tasks. In addition, candidate tests will be given to selected Air Force populations to determine the impact of selection tests on the recruitable personnel resource. By using a multivariate test procedure, a unique set of assignment criteria tailored to specific job demands can be developed for each Air Force job. The data gathered for this report are part of the Phase II effort.

Phase III of the program involves the design of the test equipment. It must be economical since there are at least 67 MEPS. It must be reliable and easily calibrated and operated by technician personnel available at the test sites. Above all, the test equipment must be safe for both the operator and subject.

Phase IV of the program will be a validation study of Phases I, II, and III in which tests will be administered to incumbents with known performance.

PROCEDURE

SUBJECTS

Because the purpose of weight lift testing performed for this study was to aid in the development of physical standards for assigning personnel to Air Force jobs, subjects were selected from among those just entering the Air Force. Since these were military subjects, special procedures were employed to prevent coerced participation, overmotivation of the subjects, or participation by physically fragile persons.

Basic Military Training (BMT) for the Air Force is a six-week program conducted at Lackland Air Force Base in San Antonio, Texas. Basic trainees are organized into Flights of from 40 to 50 members on the first day, and are administered in Flight units thereafter. The subjects in this study were 2132 male basic trainees from 63 Flights during their fifth day of training and 1178 female basic trainees from 40 Flights during their sixth day of basic training. These represented all of the female Flights beginning training during the one and one-half month period of data collection. The 63 male Flights were selected at random during the same period.

The age range for enlistment in the Air Force is 17 to 35 years. The age range for male subjects in this study was from 17 to 33 years with a mean of 19.75. More than 90 percent of the males were in the 17 to 22 age group. The older subjects were entering the Air National Guard or the Air Force Reserves. The age range for the female subjects was 17 to 35 years, with a mean of 20.61 years. More than 90 percent were 17 to 25 years old.

Flights were selected for testing one or two days prior to taking the test so that the medical records could be reviewed to determine the subjects' eligibility for testing. Relevant information was recorded by medical technicians on each subject. A sample Data Form is shown in Appendix II. Basic trainees were exempted from the weight lift study if medical histories revealed musculoskeletal problems such as back pain or injuries, broken bones, dislocations of joints, chronic muscular aches, arthritis, hernia, or hemorrhoids. Any occurrence of back pain within the six months prior to testing was a cause for exclusion.

All subjects in this study wore the standard Air Force utility uniform consisting of long sleeved shirt, trousers, and high top boots.

SUBJECT SCREENING

Each subject participated in only one test — either the Incremental Weight Lift Test or the Weight Holding Test.

When a Flight of potential subjects arrived at the test location, they were divided into two groups, one group for each of the two tests. As the trainees entered the instruction room in a single file, individuals were directed to alternating groups. Flights are ordered by stature in the ranks, and dividing the subjects in this manner precluded clustering of short or tall subjects in one group. Figure 1 shows a block diagram of the flow of subjects through the testing facility.

Two types of instructions were issued. First, a six-minute sound/slide audio-visual presentation introduced the testing program, and then sequentially gave instructions to each of the two groups on the two tests. The text of the audio-visual instructions is in Appendix III. The second set of test specific instructions was incorporated into the subject's consent forms (see Appendixes IV and V). Both the audio-visual and written instructions stressed several factors relating to safety:

- Participation by the subjects was voluntary. There were neither rewards for participation, nor penalties for nonparticipation.
- The subject's anonymity was insured. The trainees' Flight Technical Instructor was not allowed to be present during subject interviews or testing. The testing was performed in private, with only the subject and the test conductor present. Subjects who did not volunteer were not made conspicuous, but treated in the same manner as those volunteering.
- Trainees with a history of certain medical problems or physical fragilities were not tested. Subjects were advised not to conceal the existence of such conditions, and the confidential treatment of this information was insured.
- Trainees were informed that they were to be the sole judge of safe limits on the test performance. No encouragement was given at any time to exceed self-imposed limits.

BLOCK DIAGRAM OF SUBJECT FLOW THROUGH TESTING FACILITY

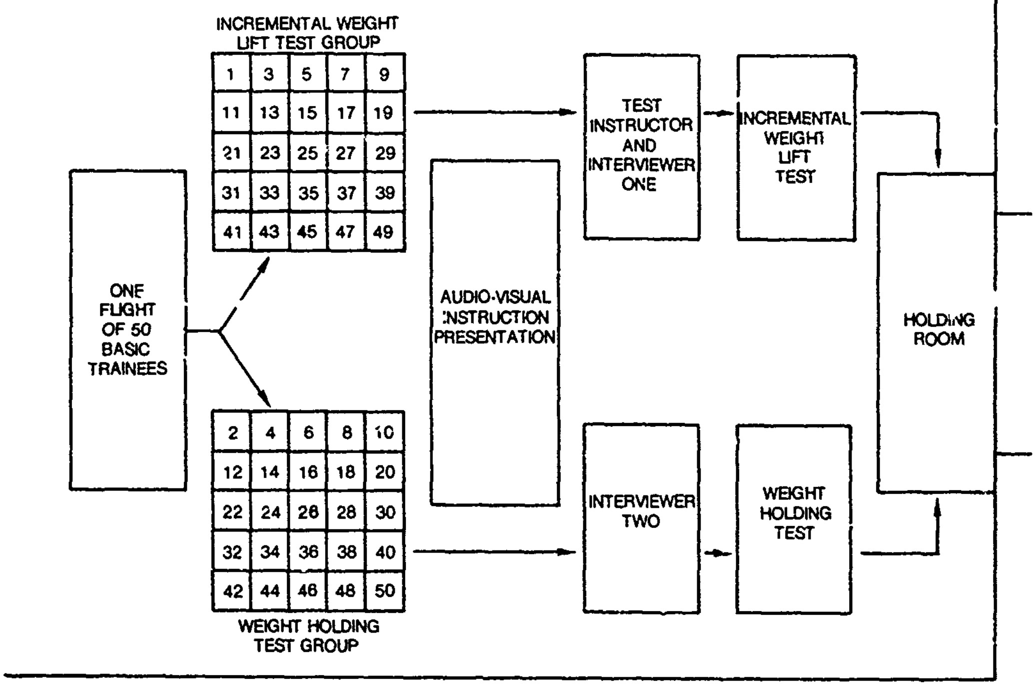


FIGURE 1. BLOCK DIAGRAM OF SUBJECT FLOW THROUGH TESTING FACILITY

After reading the consent forms, trainees were individually called by one of two interviewers (one was the Test Instructor) to complete the Supplementary Medical History Form (see Appendix VI). The interviewer asked the medical review questions and if the subject answered any question in the affirmative, indicating the existence of a medical problem, he or she was not eligible for testing. "YES" answers during the medical history interviews were accepted without qualification, and treated as a categorical rejection for testing. Had those individuals been given a physical examination, most would probably have been declared fit for testing. However, since the number of potential subjects was very large and since medical examinations are time consuming and expensive, the arbitrary disqualification technique was both expedient and safe.

Ineligible subjects were directed to the testing room, but with an unwitnessed consent form. If the subject was eligible and agreed to volunteer for testing, the subject signed the consent form and the interviewer signed as first witness.

When the subject arrived at the testing room, all forms and papers were given to the Test Conductor. The Test Conductor signed the consent form as second witness if, and only if, the first witness's signature was present confirming that the subject was eligible for testing. If the subject was not eligible, the Test Conductor kept the papers and sent the excused subject on to the holding room; if the subject was eligible, the test was given and then the subject was sent to the holding room. Subjects were tested individually and out of sight of other subjects.

To all outward appearances, eligible and ineligible or unwilling subjects followed the same procedures, thus preventing any stigma associated with not actually taking the test. The holding room was located at some distance from the instruction room to avoid any communication between subjects who had completed the procedure and those waiting to take the tests.

Since interviews and two tests were conducted concurrently, the total testing time per Flight was between 30 and 60 minutes.

THE INCREMENTAL WEIGHT LIFT TEST: APPARATUS

The test apparatus for the Incremental Weight Lift Test is shown in Figure 2. This apparatus was designed specifically for this study, but is similar to exercise machines found in gymnasiums and health spas. The weights themselves can be coupled to a carriage assembly which moves vertically in heavy metal channels on ball-bearing rollers. The handles, which the subjects hold to raise the weights, are attached to the carriage assembly, and are offset toward the subject so that the subject is not near the moving carriage and weights. The weights are retained within the upright channels so there is no possibility of dropping the weights on one's foot or on the Test Conductor's foot.

The handle and carriage assembly weigh 40 pounds, and from zero to 16 ten-pound weight plates can be coupled to the carriage assembly by inserting a metal pin beneath the number of weights to be lifted. The capacity of the apparatus is from 40 to 200 pounds in 10-pound increments. The weights themselves are obscured from the subject's view by a cover, shown removed in Figure 2. This prevents the subject from knowing how much weight he or she is lifting. The pin to select the weights is inserted from the back side of the weight lift apparatus, also out of the subject's view.

The handgrips are 1.25 inches in diameter, with a knurled surface designed for a positive grip. The handgrips, which rotate freely on the shaft, have an open area of 16 inches between the grips. This allows the subject's knees to clear the handgrips as the weight is raised and lowered. The open area also prevents interference between the handles and the subject's head. The handles begin at a position one foot above the floor and can be raised to more than seven feet above the floor before contacting rubber bumpers. The subjects were not required to raise the handles above 6 feet, but an over-run area was desirable so that the weight was not constantly banged against the upper mechanical limit.

The weight lift machine is free standing and is mounted on a 30 × 48 inch platform, which also serves as the standing surface for the subjects. The standing surface is carpeted, to provide a high-friction footing.

THE INCREMENTAL WEIGHT LIFT TEST: PROCEDURE

The purpose of the Incremental Weight Lift Test was to measure maximum safe weight lift capability. The Test Conductor set the weight machine for a 40-pound lift and instructed the subject to assume the proper starting position as illustrated in Figure 3A: Overhand grip with palms down, arms straight, knees bent, body as vertical as possible. The subject then raised the handles to a height of six feet or more above the standing surface, as shown in Figure 3C. As soon as the Test Conductor verified that the handles were at or above six feet, the subject was instructed to lower the handles.

The weight was increased to 50 pounds and the subject raised the handles again. The test was continued in this manner, increasing the weight by 10 pounds at each attempt until: (1) the subject elected to stop, (2) the subject was unable to raise the weight to six feet, or (3) the 200 pound weight capacity was exceeded. If the subject attempted but failed to raise a weight to six feet, the value of the previous successful lift was recorded as the subject's maximum safe lift capability to six feet.

If the last lift was at or above the height of the subject's elbow the subject was invited to attempt to raise a larger weight to elbow height (see Figure 3B). If the subject elected to continue, the weight was sequentially increased in 10 pound units until: (1) the subject elected to stop, (2) the subject was unable to raise the weight to elbow height, or (3) the 200 pound weight capacity was exceeded. If the subject attempted but failed to raise any weight to elbow height, the previous succesful lift was recorded as the subject's maximum safe lift capability to elbow height.

Except in such cases (less than one percent) where a subject's grip slipped and he or she performed a faulty lift for reasons other than lack of strength, subjects were not routinely allowed a second attempt to lift any weight. Although, in many cases a second attempt would have been successful, limiting the test to one attempt eliminated such uncontrolled variables as motivation and technique.

The subjects were not told how much weight they had lifted. They did not know that the starting level was 40 pounds, or that the increments were 10 pounds. The weights themselves were obscured from the subject's view, so they could not see how many weight plates were attached to the carriage assembly. Knowledge of results was withheld to prevent the subjects from competing with one another and to prevent overmotivation on the part of individual subjects.

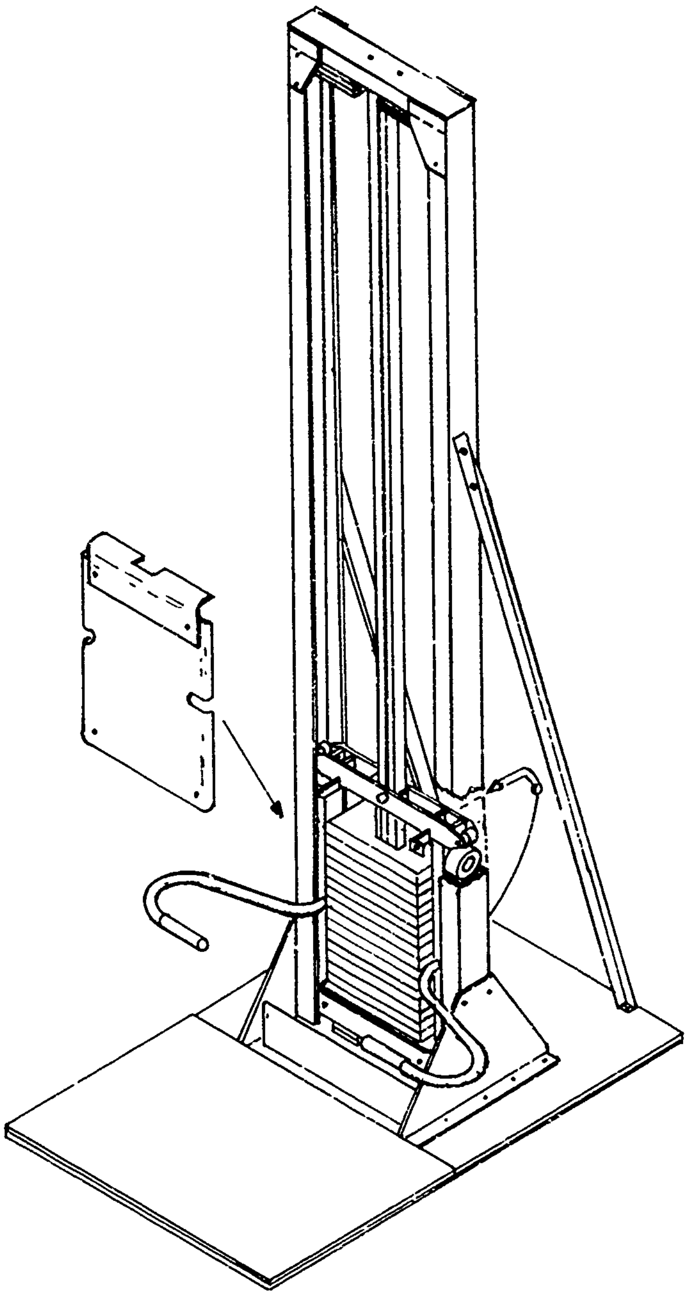
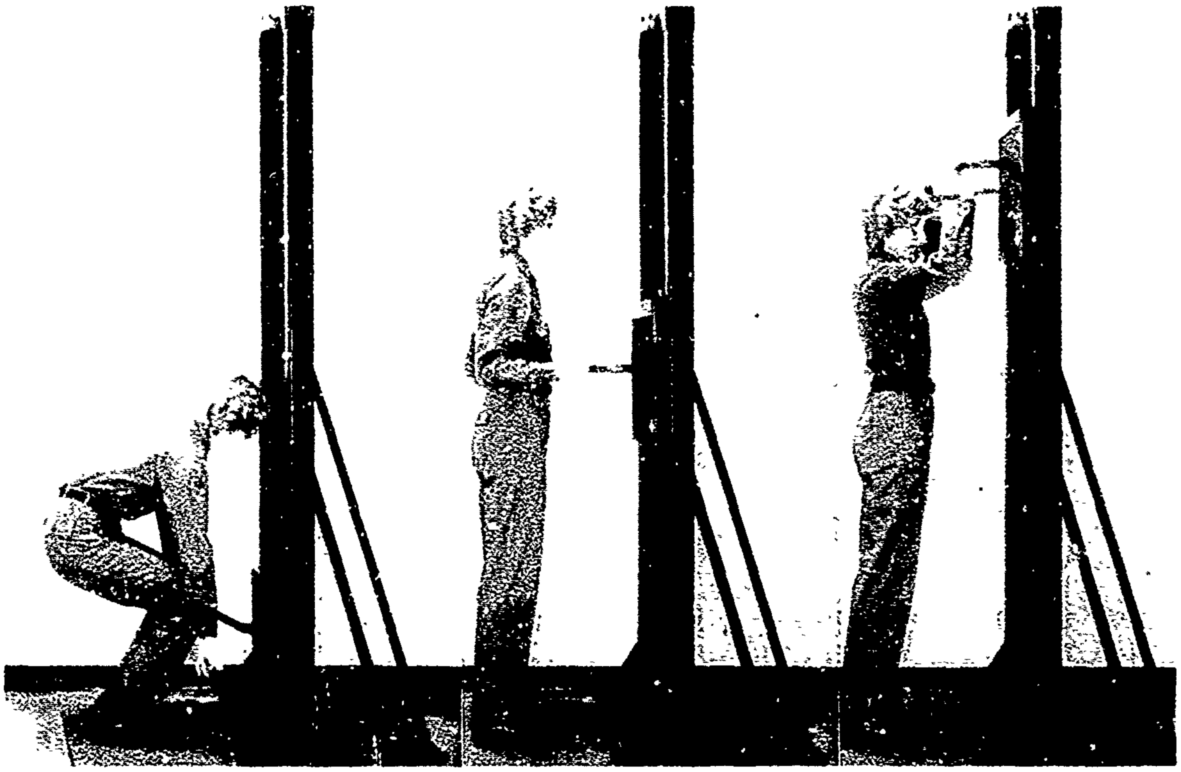


FIGURE 2. INCREMENTAL WEIGHT LIFT MACHINE. (CUTAWAY SHOWS BALL BEARING ROLLERS ALSO, THE BARRIER HAS BEEN REMOVED TO EXPOSE THE STACK OF WEIGHTS)



3A 3B 3C

FIGURE 3. CORRECT PROCEDURE FOR PERFORMING THE INCREMENTAL WEIGHT LIFT

WEIGHT HOLDING TEST

The Weight Holding Test is essentially a static endurance test and important for two reasons. First, holding a weight while carryng or positioning it is frequently identified as a major requirement of heavy work jobs. Secondly, weight holding as an endurance measure causes rapid fatigue, so that the zero-to-two minute range of endurance is short enough to be feasible in the MEPS test environment.

The 1066 male subjects and 573 female subjects who participated in the Weight Holding Test were not the same subjects who participated in the Incremental Weight Lift Test. The sample sizes of the two tests are similar because the group of potential subjects was split into two groups prior to testing. That 48.7 percent (rather than 50 percent) of the female pool took the Weight Holding Test was due to a random fluctuation in the number of disqualifications and volunteers.

The test apparatus used for this test was similar to that used in the Incremental Lift Test except that the weight machine only had three weights: 20, 40, and 70 pounds.

It was, in fact, the type of machine used at the MEPS to perform the Factor-X Test. For the Weight Holding Test, only the 40 and 70 pound weights were used. In this case, the weights were visible to the subjects, and the subjects were told in the insructions that the weights were 40 and 70 pounds, but were not informed of their endurance scores.

The purpose of the Weight Holding Test was to measure how long (in seconds) a subject was able to hold a 70 pound weight at elbow height.

The subject was asked to stand adjacent to the machine to determine and mark the subject's elbow height, as shown in Figure 4. This was indicated by a clamp-on marker six inches in height. The center of the marker was positioned at the subject's elbow height, and the range represented elbow height plus and minus three inches.

The subject was then asked to assume the proper starting position with an underhanded (palm up) grip on the handle. The 40 pound weight was selected, and the subject raised the handles to elbow height (plus or minus three inches) and immediately lowered it. This was simply for practice, so that the subject could get the feel of the apparatus.

Then the 70 pound weight was selected, and the subject raised the weight to elbow height and held it there as long as he or she was able to do so. As soon as the pointer on the handle assembly entered the range of the elbow height marker, a timer was started. As soon as the pointer on the handle assembly dropped below the elbow range marker, the timer was stopped. Time was measured and recorded to the nearest whole number of seconds. If the subject was unable to raise the 70 pound weight to elbow height (minus three inches), a score of zero was recorded. The subjects were not informed of their endurance score.

FIGURE 4. LEFT, PROCEDURE FOR LOCATING THE ELBOW HIGH TARGET. RIGHT, A SUBJECT HOLDS THE HANDLES AT ELBOW HEIGHT.

RESULTS

WEIGHT LIFT TO SIX FEET

The maximum safe weight lifted to six feet by the incremental method is described in Figure 5 which shows a distribution of subjects weighted to reflect the male/female proportions in the 1980 Air Force population — 82% male and 18% female. Thus, the "male curve" in Figure 5 shows results obtained by the 1066 male subjects, scaled to represent the relative numbers of males in the (1980) USAF population, while the "female" curve shows results obtained by 605 female subjects scaled to represent the relative numbers of females in the total 1980 USAF population.

Note that the male and female distributions cross at the 70 pound level, with very little overlap between the two distributions. While 90 percent of the female subjects were unable to lift 70 pounds to six feet, only about one percent of the male subjects failed to do so.

As can be seen in Figure 5, the distribution of personnel is bimodal, indicating a large difference in the weight lift capabilities of male and female subjects. Comparing the means, the female weight lift to six feet is 50 percent of the male capability. While this difference is striking, it is not unexpected. In a survey of static arm strength by Laubach (1976), various arm strength measures for women ranged from 47 to 79 percent of the corresponding male values. For purposes of job assignments, the important point is the lack of overlap between the distributions of male and female upper body strength. This implies that tasks requiring upper body strength which are marginally achievable by male workers would be totally beyond the capabilities of most female workers.

The weight lift distributions are skewed toward the larger weights. This is typical of strength characteristics, because while there is a moderate lower limit, the upper limit is set by experienced weight lifters who can exceed 500 pounds in this type of lift.

Table 3 presents the data in Figure 5 in a cumulative frequency format for percent failing and percent passing at each of the 10 pound increments of the weight lift test. Separate distributions are shown for male, female, and combined populations.

Table 4 shows the weight lifted to six feet in a different format. Here the distributions are described as percentiles which were calculated from a smoothed continuous frequency distribution. The 50th percentile is 111 pounds. This means that half of the male subjects could lift weights below this value, while half could lift weights at or above this value. Similarly, five percent of the male subjects could lift up to 82 pounds, while 95 percent could lift 82 or more pounds.

Comparing the male and female distributions, it can be seen that the weight lift capability of the female is about half that of the males.

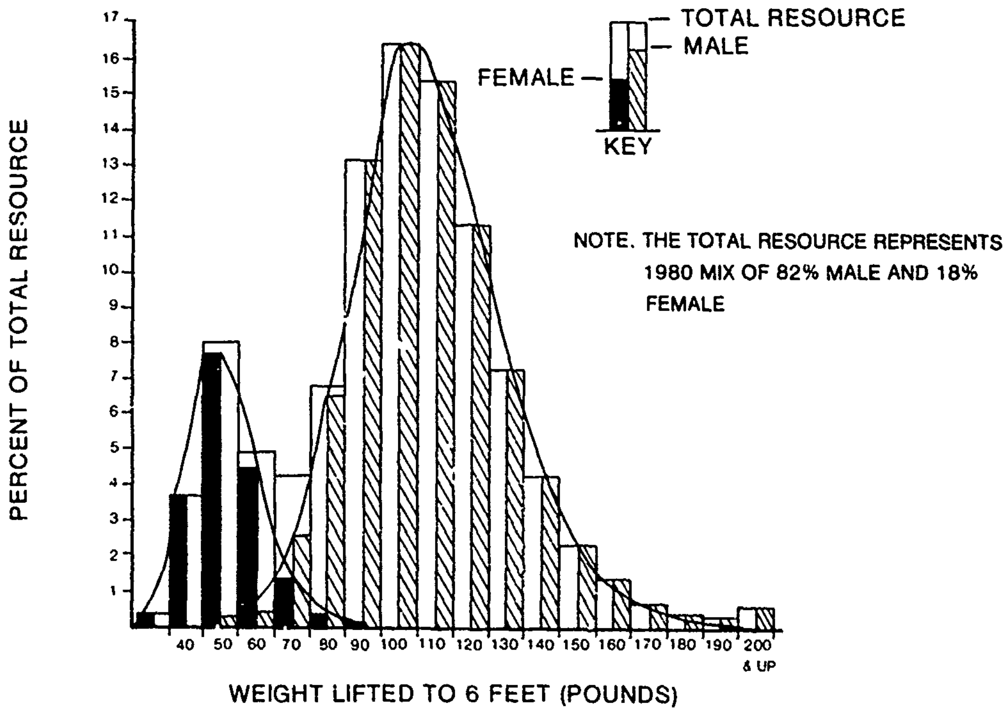


FIGURE 5. WEIGHT LIFT CAPABILITY OF AIR FORCE BASIC TRAINEES: WEIGHTED TOTAL, MALE AND FEMALE DISTRIBUTIONS

TABLE 3. CUMULATIVE PASS/FAIL DISTRIBUTIONS FOR INCREMENTAL WEIGHT LIFT TO SIX FEET

WEIGHT LIFTED POUNDS	MALES PERCENT FAILING	MALES PERCENT PASSING	FEMALES PERCENT FAILING	FEMALES PERCENT PASSING	COMBINED PERCENT FAILING	COMBINED PERCENT PASSING
40			1.7	98.3	.3	99.7
50	.0	100.0	22.2	77.8	4.0	96.0
60	.3	99.7	65.0	35.0	11.9	88.1
70	.8	99.2	89.8	10.2	16.8	83.2
80	4.0	96.0	97.9	2.1	21.0	79.0
90	11.8	88.2	99.5	.5	27.6	72.4
100	27.5	72.5	100.0	.0	40.5	59.5
110	47.3	52.7			56.8	43.2
120	65.7	34.3			71.9	28.1
130	79.4	20.6			83.1	16.9
140	88.1	11.9			90.3	9.7
150	93.3	6.7			94.4	5.6
160	96.1	3.9			96.8	3.2
170	97.8	2.2			98.1	1.9
180	98.6	1.4			98.8	1.2
190	99.2	.8			99.3	.7
200	99.5	.5			99.6	.4
MEAN (pounds)	114.14		56.92			
S.D. (pounds)	23.18		11.75			
NUMBER	1066		605			

TABLE 4. WEIGHT LIFTED TO SIX FEET

PERCENTILE	MALES POUNDS	MALES KILOGRAMS	FEMALES POUNDS	FEMALES KILOGRAMS
1	68	30.9	39	17.7
5	82	37.2	44	20.0
10	88	39.9	46	20.9
20	96	43.6	49	22.2
30	101	45.8	52	23.6
40	106	48.1	54	24.5
50	111	50.4	56	25.4
60	116	52.6	59	26.8
70	123	55.8	62	28.1
80	130	59.0	65	29.5
90	143	64.9	70	31.8
95	155	70.3	75	34.0
99	185	83.9	85	38.6
MEAN	114.14	51.79	56.92	25.83
S.D.	23.18	10.52	11.75	5.33
MINIMUM	50	22.7	<40	<18.1
MAXIMUM	>200	>90.7	90	40.8
NUMBER	1066		605	

WEIGHT LIFT TO ELBOW HEIGHT

After the subjects had completed the incremental weight lift to six feet, they were asked to lift a larger weight to elbow height. If they elected to continue, weights were added in 10 pound increments as before until the subject elected to quit or was unable to lift the selected weight to elbow height. The results of this test are shown in Table 5. Table 6 shows the same data expressed in percentile units.

It is well known that an individual's weight lift capability is inversely proportional to the height to which the weight is lifted (Emanuel et al. 1956, Switzer 1962), so it was expected that values obtained in the Weight Lift to Elbow Height Test would be higher. As can be seen, by comparing Tables 4 and 6, *on the average* males lifted 15 more pounds to elbow height than to six feet, and females lifted about 11 pounds more to elbow height. However, fully a quarter of the male subjects and almost that many female subjects were unable or unwilling to lift a larger weight to elbow height than to six feet. This can be seen on Table 7 which shows the distribution of differences in the weights lifted to both levels.

Since the weight lift to elbow height was always performed after the weight lift to six feet, the elbow height lifting performance may have been depressed by fatigue effect.

TABLE 5. CUMULATIVE PASS/FAIL DISTRIBUTIONS FOR INCREMENTAL WEIGHT LIFT TO ELBOW HEIGHT

WEIGHT LIFTED POUNDS	MALES		FEMALES		COMBINED	
	PERCENT FAILING	PERCENT PASSING	PERCENT FAILING	PERCENT PASSING	PERCENT FAILING	PERCENT PASSING
40			1.0	99.9	.2	99.8
50	.0	100.0	7.0	93.0	1.3	98.7
60	.2	99.8	26.8	73.2	5.0	95.0
70	.3	99.7	61.5	38.5	11.3	88.7
80	.9	99.1	83.1	16.9	15.7	84.3
90	3.6	96.4	94.9	5.1	20.0	80.0
100	9.8	90.2	99.0	1.0	25.8	74.2
110	21.4	78.6	99.7	.3	35.5	64.5
120	37.3	62.7	100.0	.0	48.6	51.4
130	54.6	45.4			62.8	37.2
140	69.7	30.3			75.1	24.9
150	82.9	17.1			86.0	14.0
160	89.6	10.4			91.5	8.5
170	94.7	5.3			95.6	4.4
180	97.1	2.9			97.6	2.4
190	98.2	1.8			98.5	1.5
200	99.2	.8			99.3	.7
MEAN (pounds)	129.07		67.66			
S.D. (pounds)	24.60		13.91			
NUMBER	1066		605			

TABLF 6. WEIGHT LIFTED TO ELBOW HEIGHT

PERCENTILE	MALES POUNDS	MALES KILOGRAMS	FEMALES POUNDS	FEMALES KILOGRAMS
1	80	36.3	40	18.1
5	93	42.2	48	21.8
10	100	45.4	52	23.6
20	109	49.5	58	26.3
30	116	52.6	61	27.7
40	122	55.4	65	29.5
50	127	57.6	68	30.9
60	133	60.3	71	32.2
70	140	63.5	75	34.0
80	150	68.1	78	35.4
90	160	72.6	85	38.6
95	171	77.6	90	40.8
99	197	89.4	100	45.4
MEAN	129.07	58.56	67.66	30.70
S.D.	24.60	11.16	13.91	6.31
MINIMUM	50	22.7	<40	<18.1
MAXIMUM	>200	>90.7	100	49.9
NUMBER	1066		605	

TABLE 7. DIFFERENCE BETWEEN WEIGHT LIFTED TO ELBOW HEIGHT AND WEIGHT LIFTED TO SIX FEET

PERCENTILE	MALES POUNDS	MALES KILOGRAMS	FEMALES POUNDS	FEMALES KILOGRAMS
1	0	.0	0	.0
5	0	.0	0	.0
10	0	.0	0	.0
20	0	.0	0	.0
30	2	0.9	2	0.9
40	5	2.3	3	1.4
50	8	3.6	5	2.3
60	11	5.0	7	3.2
70	16	7.3	9	4.1
80	21	9.5	12	5.4
90	28	12.7	15	6.8
95	33	15.0	19	8.6
99	44	20.0	28	12.7
MEAN	14.93	6.77	10.74	4.87
S.D.	12.84	5.83	8.00	3.63
MINIMUM	.0	.0	.0	.0
MAXIMUM	70.0	31.8	40.0	18.15
NUMBER	1066		605	

SEVENTY POUND WEIGHT HOLD AT ELBOW HEIGHT

The results of the endurance test in terms of the number of seconds a 70 pound weight can be held at elbow height (plus or minus three inches), are described in Figure 6, which shows a distribution of subjects weighted to reflect the male/female proportion of the 1980 Air Force population.

Table 8 shows that, on the average, weight holding endurance for the female was about one fifth of the male value. Twenty-five percent of the females were unable to raise the 70 pound weight to elbow height, and thus have assigned values of zero. The shortest male endurance was two seconds.

A different but equivalent group of subjects took the 70 pound Weight Hold at Elbow Height Test. Since 25 percent of the female subjects failed to lift the 70 pound weight to elbow height, 70 pounds is the 25th percentile of that population. For the Incremental Weight Lift to Elbow Height Test, the 25th percentile female value was 60 pounds, or 10 pounds less. This 10 pound difference could be due to fatigue buildup in the lift test, as noted previously, but the differences in the lifting and holding grips may also be a contributing factor. For the weight lift test, the subjects used an over-handed grip, which is more efficient for overhead lifting. For the Weight Holding Test, the subjects used an under-handed grip, which is more efficient for lifting below shoulder height. Because of these grip differences, it is not possible to determine which, if any, portion of the 10 pound difference may be due to fatigue.

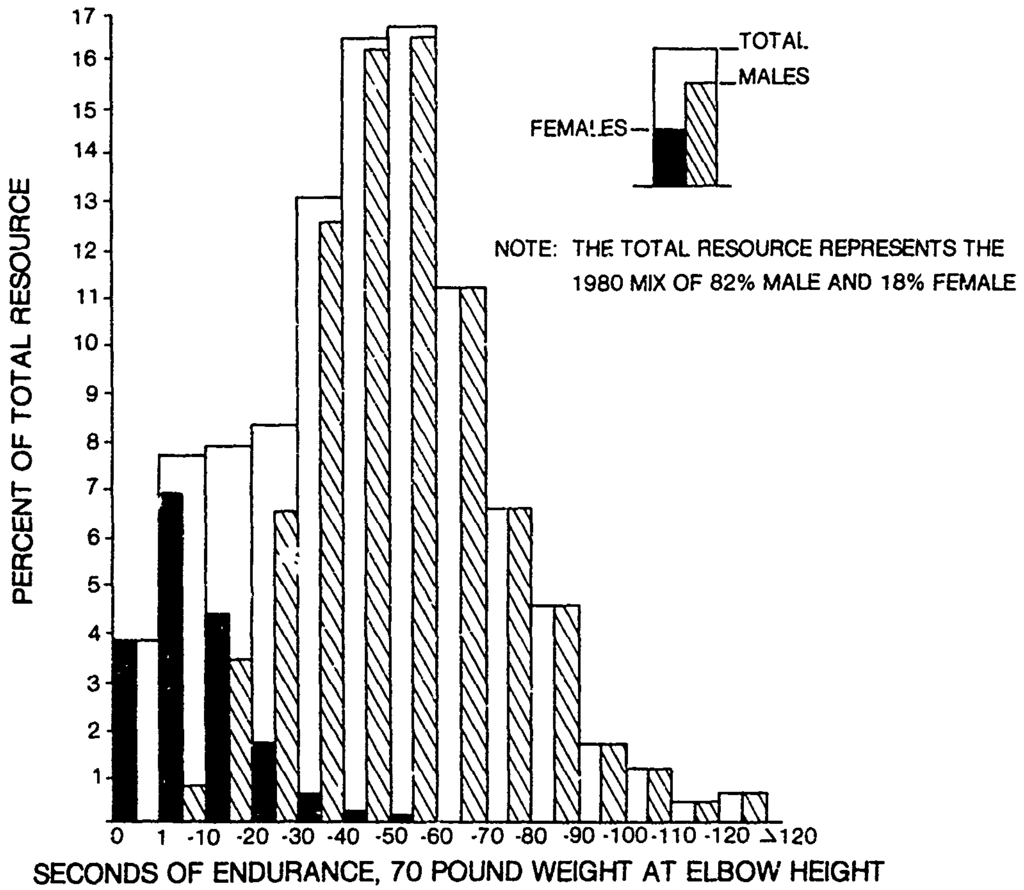


FIGURE 6. SEVENTY POUND WEIGHT HOLDING ENDURANCE OF AIR FORCE BASIC TRAINEES: WEIGHTED TOTAL, MALE AND FEMALE DISTRIBUTIONS

TABLE 8. SEVENTY POUND WEIGHT HOLDING CAPABILITY: ENDURANCE IN SECONDS

PERCENTILE	MALE	FEMALE
1	8	0
5	19	0
10	25	0
20	33	0
30	39	1
40	44	3
50	49	6
60	54	8
70	60	12
80	67	17
90	78	24
95	88	30
99	110	44
MEAN	53.33	10.30
S.D.	22.11	10.54
MINIMUM	2	0
MAXIMUM	207	60
NUMBER	1066	573

CORRELATIONS

Tables 9A and 9B show the correlations between selected variables for male and female subjects taking the Incremental Weight Lift Test. There was a high correlation between Weight Lifted to Six Feet and Weight Lifted to Elbow Height (0.86 for males and 0.82 for females). These values are typical of correlations between dynamic lifting tasks, including the more complex lifting associated with manual materials handling. There was a low negative correlation between Weight Lifted to Six Feet and Elbow Difference — that is, the amount of additional weight the subject lifted to elbow height. As noted previously, 25 percent of the male subjects had an Elbow Difference of zero. Examining the strongest subjects, however, it can be seen that 50 percent of male subjects who lifted 140-200 pounds to six feet did not lift a larger weight to elbow height; that is, they had an Elbow Difference of zero. The average Elbow Difference for this group is about five pounds less than the total male sample. At this end of the spectrum, subjects had lifted 10 or more weights prior to attempting the elbow height lift. This five pound decrement in the Elbow Difference scores could very well be the result of fatigue. Note also that correlation between Weight Lifted to Six Feet and Elbow Difference for females was not different from zero.

The correlation between Body Weight and Height for males (r = 0.53) and females (r = 0.60) is consistent with data on previous populations of military subjects. This is somewhat larger than height/weight correlations for the civilian population because of the weight limitations imposed by enlistment standards for the Air Force.

The correlations between Body Height and Weight Lifted to Six Feet are very low: 0.21 for males and 0.20 for females.

The correlations between Body Weight and Weight Lifted to Six Feet are somewhat higher — 0.49 for males and 0.36 for females — but are of little value for predictive purposes. This effect is best illustrated by Tables 10A and 10B, which show bivariate frequency distributions of Weight Lifted to Six Feet versus Body Weight for male and female subjects respectively. These tables reveal that some individuals with a body weight at or below the 10th percentile lifted weights at or above the 90th percentile, while some individuals with body weight at or above 90th percentile could not lift weights above a 10th percentile value. This demonstrates that while there is a positive relationship between body weight and strength, it is not large enough to permit individuals to be assigned to heavy work jobs based on body weight.

The correlations between Age and Weight Lifted are too low to be of any predictive significance. However, Age, and Weight Lifted is positively correlated for the males and negatively correlated for the females. This suggests that males may get slightly stronger as they mature, while females do the opposite. In a study of age versus grip strength, Montoye and Lamphiear (1977) found that both males and females began to decline in strength after age 30. The low negative correlation for the female subjects may, therefore, be accounted for by the relatively larger portion of 30 to 35 year olds in the sample, as compared to the males.

Tables 11A and 11B show the correlations between selected variables for male and female subjects in the 70 pound Weight Holding Test. The correlations between Height and Weight for these two groups of subjects are not significantly different from the corresponding correlations from the Incremental Lifting Test group.

The correlations between Weight Holding and Body Weight (r = 0.27 for males and 0.18 for females) are statistically significant, but too small to be of any predictive value.

Table 11B shows the negative correlation between Age and Weight Holding endurance for females. This is similar to the result obtained for the weight lift group. The magnitude of the male correlation was just under the cutoff for significance but was positive, rather than negative, also consistent with the relation found on the Incremental Lift Test.

TABLE 9A. CORRELATION MATRIX FOR VARIABLES OF 1066 MALE SUBJECTS IN THE INCREMENTAL WEIGHT LIFT TEST

VARIABLE	VARIABLE NUMBER 1	2	3	4	5	6
1. HEIGHT	1.00	.53	.00	.21	.19	.00
2. WEIGHT	.53	1.00	.16	.49	.47	.00
3. AGE	.00	.16	1.00	.06	.07	.00
4. WT. LIFT-6 FEET	.21	.49	.06	1.00	.86	-.16
5. WT. LIFT-ELBOW HT.	.19	.47	.07	.86	1.00	.37
6. ELBOW DIFFERENCE	.00	.00	.00	-.16	.37	1.00

TABLE 9B. CORRELATION MATRIX FOR VARIABLES OF 605 FEMALE SUBJECTS IN THE INCREMENTAL WEIGHT LIFT TEST

VARIABLE	VARIABLE NUMBER 1	2	3	4	5	6
1. HEIGHT	1.00	.60	-.09	[illegible]	.23	.11
2. WEIGHT	.60	1.00	.00	.36	.40	.17
3. AGE	-.09	.00	1.00	-.00	-.09	.00
4. WT. LIFT-6 FEET	.20	.36	-.00	1.00	.82	.00
5. WT. LIFT-ELBOW HT.	.23	.40	-.09	.82	1.00	.53
6. ELBOW DIFFERENCE	.11	.17	.00	.00	.53	1.00

NOTE: Correlations which were not significantly different from zero ($p < .05$, two tailed t-test) have been replaced with zero.

TABLE 10A. BIVARIATE FREQUENCY DISTRIBUTION: WEIGHT LIFTED TO SIX FEET VERSUS BODY WEIGHT FOR 1066 MALE SUBJECTS

A BIVARIATE FREQUENCY TABLE FOR
WEIGHT LIFT TO 6 FT AND BODY WEIGHT
FACTOR X MALES

WEIGHT LIFT TO 6 FT(LB)

BODY WEIGHT(LB)	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0	100.0	190.0	200.0	TOTAL
225.0							1										1
220.0							1										1
215.0						1	1	3	1						1	1	8
210.0					1		1		3							1	6
205.0						2	2	4	3	1				2			14
200.0					1		5	8	2	2	1	2		1	1		23
195.0			1	1	2	2	5	2	3	4	3	4	1	1	1		30
190.0				3	4	6	7	13	4	4	2	2	1		1		47
185.0					5	6	12	8	3	2	1	1	1			1	40
180.0			1	1	5	10	12	14	10	6	4	2	3	2			70
175.0				3	5	9	13	9	8	5	2	3				1	58
170.0					7	13	11	14	7	9	6	1				1	69
165.0			1	4	5	23	16	14	9	8	1	1	1				83
160.0	1	1		4	17	12	25	9	15	5	1		1				91
155.0	1			2	14	22	12	16	10	1	5	1	1				85
150.0			2	9	16	31	24	10	5	2		1					100
145.0			2	12	21	17	23	9	3	1	3						91
140.0			9	8	20	23	16	5	4	3	1						89
135.0			2	14	17	15	6	5	1	2							62
130.0		1	1	7	11	8	3	1	1								33
125.0		1	9	6	9	5		1	1								31
120.0		1	3	6	3	4											17
115.0			3	1	3	1											8
110.0	1		1	2				1									5
105.0		1	1		1	1											4
100.0																	
TOTAL	3	5	35	83	167	211	196	146	93	55	30	18	9	6	4	5	1066

TABLE 10B. BIVARIATE FREQUENCY DISTRIBUTION: WEIGHT LIFTED TO SIX FEET VERSUS BODY WEIGHT FOR 605 FEMALE SUBJECTS

A BIVARIATE FREQUENCY TABLE FOR
WEIGHT LIFT TO 6 FT AND BODY WEIGHT
FACTOR X FEMALES

WEIGHT LIFT TO 6 FT(LB)

BODY WEIGHT(LB)	40.0	50.0	60.0	70.0	80.0	90.0	100.0	TOTAL
170.0				1				1
165.0				3				3
160.0			2	7	2	1		12
155.0		2	8	9	1			20
150.0		1	12	13	5	3	1	35
145.0		4	22	19	8	1		54
140.0		11	31	21	10	1		74
135.0		9	31	13	5	1	1	60
130.0	1	19	47	19	7	2		95
125.0	1	16	31	13	3		1	65
120.0	1	16	29	14	6			66
115.0	3	20	21	9	1	1		55
110.0		12	10	6	1			29
105.0	2	7	9	3				21
100.0	1	4	5					10
95.0	1	3	1					5
90.0								
TOTAL	10	124	259	160	49	10	3	605

TABLE 11A. CORRELATION MATRIX FOR VARIABLES FOR 1066 MALE SUBJECTS IN THE WEIGHT HOLDING TEST

VARIABLE	VARIABLE NUMBER 1	2	3	4
1. HEIGHT	1.00	.55	.00	.19
2. WEIGHT	.55	1.00	.10	.27
3. AGE	.00	.10	1.00	+.00
4. WT. HOLD (SEC.)	.19	.27	+.00	1.00

TABLE 11B. CORRELATION MATRIX FOR VARIABLES FOR 573 FEMALE SUBJECTS IN THE WEIGHT HOLDING TEST

VARIABLE	VARIABLE NUMBER 1	2	3	4
1. HEIGHT	1.00	.57	.00	.16
2. WEIGHT	.57	1.00	.00	.18
3. AGE	.00	.00	1.00	-.10
4. WT. HOLD (SEC.)	.16	.18	-.10	1.00

NOTE: Correlations which were not significantly different from zero ($p < .05$, two tailed t-test) have been replaced with zero.

ANTHROPOMETRY

Anthropometry (body size measurement) is an important consideration for the design of clothing and equipment for Air Force personnel. The Body Height (Stature) and Weight data reported here were transcribed from the medical examination data. These data were measured at the MEPS (Military Enlistment Processing Stations) as part of the pre-enlistment physical examination. The statures and weights of participants of this study were not remeasured at the time of the strength tests. The anthropometric data were between 6 days and 6 months old at the time of the strength testing, the majority being less than one month old. Table 12 describes the statistical representations of the stature of male and female basic trainees. Table 13 describes the statistical representations of the body weight of male and female basic trainees.

TABLE 12. STATURE OF BASIC TRAINEES

PERCENTILE	MALES INCHES	MALES CENTIMETERS	FEMALES INCHES	FEMALES CENTIMETERS
1	63.2	160.5	59.2	150.4
5	64.8	164.6	60.4	153.4
10	65.8	167.1	61.1	155.2
20	66.9	169.9	62.2	158.0
30	67.7	172.0	63.0	160.0
40	68.5	174.0	63.7	161.8
50	69.1	175.5	64.3	163.3
60	69.8	177.3	64.9	164.8
70	70.6	179.3	65.6	166.6
80	71.5	181.6	66.4	168.7
90	72.7	184.7	67.5	171.5
95	73.8	187.5	68.5	174.4
99	76.1	193.3	70.3	178.6
MEAN	69.21	175.79	64.34	163.42
S.D.	2.74	6.96	2.46	6.25
MINIMUM	60.0	152.4	56.0	142.2
MAXIMUM	81.0	205.7	73.0	185.4
NUMBER	2132		1178	

TABLE 13. BODY WEIGHT OF BASIC TRAINEES

PERCENTILE	MALES POUNDS	MALES KILOGRAMS	FEMALES POUNDS	FEMALES KILOGRAMS
1	110.6	50.2	96.2	43.6
5	122.9	55.8	103.8	47.1
10	129.2	58.6	108.5	49.2
20	137.1	62.2	114.6	52.0
30	143.4	65.1	119.2	54.1
40	149.1	67.6	123.1	55.9
50	154.7	70.2	126.8	57.5
60	160.6	72.9	130.5	59.2
70	167.1	75.8	134.5	61.0
80	175.1	79.4	139.0	63.1
90	186.1	84.4	144.9	65.7
95	194.7	88.3	146.6	67.9
99	207.4	94.1	157.4	71.4
MEAN	156.23	70.88	126.77	57.52
S.D.	21.71	9.85	13.83	6.27
MINIMUM	100	45.4	92	41.7
MAXIMUM	230	104.4	178	80.8
NUMBER	2132		1178	

DISCUSSION

When designing a test procedure to be used for job classification, the primary concerns are safety and effectiveness. The test must be safe, or it will defeat its primary purpose of reducing job related lifting injuries. The test should also be effective, that is, correlated with job related weight lifting. Other factors to be considered in the design of a strength test are (1) the motivation of test subjects which may affect the results, and (2) physical training which is commonly thought to affect the results.

Considerable attention was given to these matters in devising the tests described in this report and the questions of safety, motivation and physical training will all be addressed in some detail in this section. The differences between the currently-used Factor-X Test and the Incremental Lift and Holding Tests will also be discussed here, as will the potential impact of the new data for establishing safe weight lifting limits for manual materials handling tasks.

SAFETY CONSIDERATIONS

It is commonly believed that if lifting injuries are caused by lifting, then lifting is inherently hazardous. The idea of maximum performance weight lifting causes great misgivings among researchers. However, just as there are procedures for lifting which increase the risk of injury, there are likewise procedures which minimize that risk. The weight lift testing in the Air Force has had a safe history, and the procedure which has evolved has no greater incidence of temporary muscle soreness than that which results from isometric strength testing.

There are several elements which contribute to a safe weight lifting test. One of these is withholding knowledge of results from the subject during the test. This serves two purposes. First, it prevents overmotivation due to competition, either against others being tested, or even against oneself. If a person has lifted a 90 pound weight, there is an almost irresistible urge to try for 100 pounds, even if the safe limit has already been reached.

Another element of safe testing is the incremental nature of the test. Subjects approaching their maximum safe capability in small increments are better able to define that limit.

Certain positions are to be avoided when performing lifting tests. Lifting tasks involving lateral rotation of the trunk are hazardous. Tasks with asymmetrical loading, such as lifting with one hand, are hazardous because a scoliotic curve is induced in the lower spine which concentrates the force in smaller areas.

In dynamic weight lifting it has been repeatedly demonstrated that the most limiting range of lift is above shoulder height. In a study by Switzer (1962) maximum weight lift capability in three ranges was measured. From floor height to 18 inches above the floor, 10 subjects averaged 138 pounds; to 42 inches, 92 pounds; and 62.5 inches, 65 pounds. In a similar study by Emanuel et al (1956), 19 subjects averaged 230 pounds up to 20 inches, 119 pounds up to 44 inches, 81 pounds up to 56 inches, and 58 pounds up to 68 inches above the floor. In both of these studies, subjects lifted a weighted box and set it on a shelf. Since the weight was unstable, subjects were not able to lift as much weight safely as they could with a weight lift machine.

When using a weight lift machine to lift in the range above shoulder height, the subject's trunk will be vertical, minimizing the stress on the lower back. The arm and shoulder muscles will be providing the lifting force. Since the weight lift capability above the shoulders is about half of the lift capability near the floor (starting position), the initial weight lifted near the floor will always be far below the individual's maximum capability for that range. It is generally recognized that the stooping or squatting posture associated with lifting near the floor places the largest strain on the back, because the torque moments about the lower back are increased by the forward center of gravity of the upper body mass as well as the weight being lifted by the hands. This gives rise to the recommendations that weights should be lifted with the upper body as erect as possible, lifting with the leg muscles rather than the back. Thus, in the critical posture (stooping with the load near the floor), the Incremental Weight Lift Test does not load the subject with more than half of the subject's maximum capability while stooping and the stress is far below the structural limit associated with the stooping posture.

There are two procedural limitations commonly imposed to protect strength test subjects but which, in fact, do not improve the safety of the tests. One is an arbitrary weight ceiling, the other an arbitrary weight lift per body weight limit.

Weight lift capability is not highly correlated with body weight (0.49 for male and 0.36 for females). If one adopts an arbitrary weight ceiling based on a fraction of body weight, a great deal of data will be lost. If, for example, a weight lift ceiling of 75 percent of body weight were used, a little more than 30 percent of the male subjects could not be tested to their maximum capability. These subjects, however, are spread across the entire range of body weight. In this study only 38 male subjects (3 percent) had body weights below 120 pounds. Of these, 14 (37 percent) were able to lift more than 75 percent of their body weight, the strongest lifting more than 110 percent of body weight.

With a 75 percent of body weight limitation, these same 14 subjects would not have been allowed to attempt a weight greater than 80 pounds.

ESTABLISHING WEIGHT LIFT LIMITS FOR WORKERS

One way to control manual materials handling stress on individual workers is through the design of the job itself. The military has sought to do this by providing maximum design weight limits which one worker can lift. Table 14 shows the equipment weight limits from the Human Engineering Standard (MIL-STD-1472B) which allegedly represents a fifth percentile male capability. These values represent maximum allowable design weights for a piece of equipment with appropriate handles to be lifted by one person. These values are not meant as standards for repetitive lifting tasks, and are currently reduced by 40 percent if workers include females. Notice that the allowable weight a worker can lift is larger near the ground. This is consistent with the above-cited studies by Switzer (1962) and Emanuel et al. (1956). This standard provides for two or more workers lifting loads which may weigh more than 35 pounds. It is further assumed that if a weight is too heavy for workers, hoists or other lifting equipment will be provided. In the real workplace, however, this is frequently not the situation. A more realistic scenario involves lifting a delicate and expensive component into a small access hole in an aircraft. The access limits the number of workers to not more than two and precludes the use of any special handling equipment.

TABLE 14. DESIGN WEIGHT LIMITS FROM MIL-STD-1472B

HEIGHT OF LIFT FROM GROUND	MAXIMUM WEIGHT OF ITEM
5 ft (1.5)	35 lb (16 kg)
4 ft (1.2m)	50 lb (23 kg)
3 ft (.9m)	65 lb (29 kg)
2 ft (.6m)	80 lb (36 kg)
1 ft (.3m)	85 lb (39 kg)

The 35 pound equipment weight standard is so limiting that designers frequently get waivers or ignore it altogether. Furthermore, the current practice is to reduce these values by 40 percent when the workers may include females, which is the rule rather than the exception. Effectively, then, the equipment weight limit is 21 pounds for objects lifted above five feet.

We cannot directly compare the weight lift capabilities on the Incremental Weight Lift Test with manual materials handling because the test employs a restrained weight which is not representative of the real-world lifting. Some discount must be applied. The 5th percentile Incremental Weight Lift values for male and female subjects were 82 and 44 pounds, respectively (see Table 3). The 35 pound limit is 43 percent of the 5th percentile male lifting capability to 6 feet and the 21 pound limit for females is 48 percent of the 5th perccentile female lifting capability.

An adequate weight lift standard must consider such variables as size of the load, types of hol' ·, location of handholds, the location of the center of mass, range of lift holding time, positioning of load, and the weight of the load. However, when all these things have been considered, it is very probable that the 35 pound male and 21 pound female weight lift limits may be revised upward.

The practice of considering female weight lift capablity to be 60 percent of the male capablity is based on isometric strength measures. The data from this study suggests that 50 to 55 percent may be more realistic for weight lifting.

The lifting of an actual weight, such as was done in this study, is more similar to the weight lifting activities found in job situations than are static or isometric type lifting tests. Typically, correlations betwen dynamic weight lift scores and job related performance are 30 to 50 percent higher than static lifting scores. Dynamic lifting is clearly more relevant, and as demonstrated in this study, safe.

MOTIVATION

Since there were such great differences between the performance of male and female subjects in this test, it is important to examine such factors as motivation of the subjects to determine whether the gender related differences resulted from other than variations in strength capability. Differences due to motivation, which would affect the test results, should also be evident in other data. Three parameters should be sensitive to motivational differences: (1) the rate of self disqualification for medical reasons, (2) the proportion of nonvolunteers and (3) the proportion of individuals failing or refusing to lift more weight to elbow height than to 6 feet.

In order to prevent concealment of any disqualifying conditions, the subjects were assured that data on health problems would be kept confidential. Both male and female subjects had identical medical disqualification rates of 24 percent, as shown in Table 15. Two things are significant: first, the subjects were not hesitant about identifying disqualifying physical conditions, and second, there were no differences between males and females.

TABLE 15. SUBDIVISION OF POTENTIAL SUBJECTS INTO CATEGORIES OF DISQUALIFIED, NONVOLUNTEER AND TESTED

	MALES		FEMALES	
	NUMBER	PERCENT	NUMBER	PERCENT
Reported for Testing	2889	100	1668	100
Disqualified	69[illegible]	24	405	24
Nonvolunteers	58	2	84	5
Total Tested	2132	74	1179	71
A. Incremental Lift	1066	37	605	36
B. Weight Holding	1066	37	574	34

Participation in these tests was voluntary. Two percent of the males and five percent of the females refused to volunteer. Since the rates were low and not meaningfully different, a difference in motivation is not indicated here. In fact, several female subjects who had been disqualified from testing for medical reasons asked to be allowed to take the test anyway. They were, however, not tested.

The Incremental Weight Lift Test was a two-part test. First, the subjects were incrementally loaded until they failed, or refused, to lift a larger weight to 6 feet. Then they were asked to attempt an additional increment of weight to elbow height.

Twenty-five percent (269 out of 1066) of the males did not lift a larger weight to elbow height than they did to 6 feet. Twenty-two percent of the females (137 out of 605) did not lift more weight to elbow height. This could be attributed to two factors: (a) they were not able to lift more, or (b) they were not motivated to lift more. Often those who did not lift more weight to elbow height, did not attempt to do so. However, these frequencies are not unusual in a normal distribution (see discussion of Table 7 in the Results Section). If there was any motivation component acting on these data, it was acting on both males and females to the same degree. Altogether, relevant evidence indicates no difference in motivation between male and female subjects in this study.

PHYSICAL TRAINING

As strength capability relates to the design of military equipment and jobs, the relevant standard is MIL-STD-1472B, "Human Engineering Design Criteria for Military Systems, Equipment, and Facilities," which requires equipment to be compatible with the range of capabilities of the 5th to 95th percentile worker. The equipment weight standards have not taken female workers into account, which causes problems of accommodation since, with regard to measure weight lift capability, almost half of female population falls below 5th percentile male values. The six-foot weight lift data in this study, for example, show little overlap between the male and female distributions (see Figure 5).

This disparity raises the question of whether physical training programs could be usefully employed to bring men's and women's strength capabilities into closer correspondence.

Wilmore (1974) reported gains in dynamic strength and body composition due to a 10 week weight training program. The subjects were 47 women and 26 men from university physical education classes. The weight training consisted of eight weight lifting exercises (two involving the legs) repeated to complete fatigue twice during a 40 minute session with two sessions a week for 10 weeks. The leg strength values of men and women, as demonstrated by the leg press, were similar, and if normalized for body weight, were almost identical. Women demonstrated increases in strength of 29.5% in leg press, 10.6% in arm curl, 28.6% in bench press, and 12.8% in grip strength. Increases for males were similar. The relative curl strength of women/men went from 53 percent to 49 percent after training. The women's relative bench press strength went from 37 percent to 41 percent of man's after training. For grip strength, the women increased from 57 percent to 61 percent of the male strength. These differences in relative loss and gain are small and probably not significant. If anything, however, they demonstrate that for an absolute comparison, there is no reason to assume that the differences between women's and men's upper body strength can be eliminated by physical training.

McDaniel (1981) reported the effect of physical training on the ability of males and females to operate aircraft hand and foot controls. Fifty-five males and fifty-five females exercised three times a week for nine weeks to strengthen muscles used to operate aircraft controls. Subgroups performed isometric and isotonic exercises. Both groups show similar increase in performance indicating one type of exercise is as good as the other.

For isometric strength measures for the directions of left and right for the stick control, there were no significant increases due to either type of exercise for either sex. For left and right rudder pedals, there were considerable increases for both sexes with both types of exercise. The majority of these subjects were in good-to-excellent overall physical condition coming into the program. Where there were improvements due to exercise, males and females improved by the same amount. Weaker subjects benefited more from the physical training than stronger subjects.

On the average, male and female arm strength increased six percent due to the nine-week physical training program. As in the weight lift data reported here, there was little overlap of strength distributions for arm strength, the weaker males' (5th percentile) performances similar to the stronger females' (95th percentile). The notable exception was that weaker males and weaker females showed similar performance on the foot controls. There were no meaningfully predictive relationships between strength and anthropometric characteristics. For the four arm strength measures, the average female arm strength was 62 percent of male arm strength.

Knapick et al. (1980) reported pre- and post- basic training strength test on 769 male and 393 female Army basic trainees. The exercises consisted of calisthenics, running, and marching totaling about 39 hours over a seven-week period. On an arm strength test, a two-handed isometric pull down (similar to a chinning exercise), male subjects improved by 4.2 percent, females by 9.3 percent. On a leg extension test, a two-legged isometric foot pedal, males improved 9.7 percent; females, 12.4 percent. On a trunk extension test, an isometric back strength measure, males improved 8.1 percent; females 15.9 percent. At the end of basic training, the arm pull down strength of women averaged 60 percent of the male value.

Another way of approaching the problem of drawing up reasonable design criteria which encompass the widely diverging strength capabilities of males and females, is to determine whether physical training programs can sufficiently shift the female distribution upward so that the 5th percentile female value falls at, or close to, a 5th percentile male value.

Assuming that the variances of the distributions do not change, the magnitude of such a shift is 38 pounds for weight lift capability to six feet (see Table 3). An increase of 38 pounds of weight lift capability would require an increase in strength of 86 percent increase for 5th percentile females and, correspondingly, a 68 percent increase for 50th percentile females, and a 50 percent increase for 95th percentile females.

The studies cited above, as well as others, show that upper body strength increases for women range from one to 30 percent for physical training periods of seven to 10 weeks. Most of the increases in arm strength tend to be in the five to 10 percent range. No studies involving either male or female subjects have suggested that upper body strength increases of 50-86 percent (which would be necessary to shift the female strength distribution to the low end of the male distribution) are possible, much less feasible.

There is evidence of significant increase in weight lift capability after one to two weeks of training. This small increase is believed to result from a more efficient use of muscles, that is to say, a learning phenomenon rather than an actual increase in size or number of muscle fibers. While the magnitude of such an increase is not large, it may be enough to put an almost-passing subject over the line.

COMPARISON OF INCREMENTAL TEST RESULTS WITH FACTOR-X TEST RESULTS

There are several differences between the current Factor-X Test procedure and the Incremental Weight Lift Test procedure. One major difference lies in the motivation of the test subjects. There are several factors which motivate the subjects to "pass" the Factor-X test, which involves lifting 20, 40, and 70 pounds. These include the presence of other recruits during the testing, and the knowledge that failing the test will limit job possibilities. Since these overmotivating factors were deliberately removed from the Incremental Lift Test procedure to reduce the risk of injury to the test subjects, it was expected that there would be a difference in test scores.

Another difference between the two test procedures was the number of attempts allowed to lift the weight. In the Incremental Weight Lift testing the subjects were allowed a single attempt to lift each weight. The first failure signaled the end of the test. A small number of subjects (less than one percent) were allowed to repeat a lift following loss of grip (see Procedure Section). The subjects were instructed to lift the weight smoothly, in one motion. A test, so defined, measures strength not weight lifting technique.

The Factor-X test, as currently defined, does not have a limit on the number of attempts at any one session. Consequently, when a subject fails on the first attempt, the subject is frequently offered additional chances. If the subject can raise the weight to shoulder height, which is a stable weight holding position, the subject is frequently instructed in the "jerk" technique, whereby the weight is held stable at the shoulders, while a bounce by the knees often provides enough upward momentum to supplement strength, and therefore, allows the weight to be raised to six feet. Such a maneuver is practical only for the subjects who can raise the weight to shoulder height. While the instructions for the "jerk" technique are not described in the current Factor-X procedure, it has been observed that such instructions are often given to marginal subjects. It is also true that most female subjects who pass the Factor-X 70 pound lift test requ[illegible] more than one attempt to do so.

It can be seen from Table 2, which shows the results of the Factor-X test, that 98.8 percent of the male recruits and 25.8 percent of the female recruits passsed the test at the X-1 level, indicating they were able to lift a 70 pound weight to six feet. Selecting corresponding values from the Incremental Weight Lift Test distribution from Table 3, 98.8 percent of the male subjects lifted 70 or more pounds to six feet, indicating no difference whatever between the Factor-X and Incremental Lift Test results for males. For the female subjects, 25.8 percent (74.2nd percentile) were at or above the 63 pound level, or seven pounds less than the Factor-X sample. Seventy pounds on the female Incremental Lift distribution is a 90th percentile value, meaning that only 10 percent of the Basic Trainees were able to lift 70 pounds or more compared to 25.8 percent of the subjects who took the Factor-X test. This represents considerable difference in the pass rate.

BODY SIZE GROWTH TRENDS

While body size or anthropometric variables are not useful for predicting strength or endurance, these parameters are useful as criteria for the sizing of clothing, personal protective equipment, and the geometry of workstations. There is a growing trend in the general population, which is demonstrated by comparing the results of anthropometric surveys over the years. The stature and weight data shown in Tables 12 and 13 of the Results Section have mean values which are significantly larger than previous surveys of similar populations.

For the purpose of determining the growth trends in the population, four previous studies provide a relevant comparison.

1. U.S. Air Force Survey of 1965: includes 2527 male Basic Trainees measured at Lackland AFB; documented in Churchill et al., 1977.

2. Air Force Women Survey of 1968: includes 1905 women, of which 1347 were enlisted (although only 333 were Basic Trainees) and 558 were officers; age range was 18-56, but 92 percent were 35 years or younger; documented in Clauser, et al., 1972.

3. U.S. Air Force Basic Trainees of 1952: includes 3531 male Basic Trainees measured at Lackland AFB; documented in Daniels, Meyers, and Churchill, 1953.

4. Women of the Air Force Basic Trainees of 1952: includes 851 female Basic Trainees measured at Lackland AFB; documented in Daniels, Meyers, and Worral, 1953.

Figure 7 shows a statistical comparison of sample means for Height and Weight for relevant samples of males and females respectively. Because the relatively smaller number of female Basic Trainees in the Air Force women 1968 Survey, all females in the age range of 18-23.5 were considered. These 1393 (73 percent of the total sample) included 86 officers, 60 officer trainees, 917 enlisted, and 330 basic trainees. This gave a mean age for the 1968 subsample of 20.33 years, which is between the 20.61 years mean age for the 1981 female basics and the 19.79 years mean age for the 1952 female basics.

Figure 7 shows the longitudinal growth trends for Air Force Basic Trainees where the male data were taken in 1952, 1965, and 1981, with sampling intervals of 13 and 16 years. The female data were taken in 1952, 1968, and 1981, with sampling intervals of 16 and 13 years betwen samples. There was statistically significant growth during each interval except for the 1968 female stature, which fell below both the 1952 and 1981 population.

The female subjects showed a significant growth in weight during each interval, although it was not as great (either absolute or relative) as the males. The height pattern for females is mixed. The mean height of 63.74 inches in the 1968 sample being 0.33 inch shorter than the 1952 survey, a difference which is significant, and contrary to the expected direction of change. Overall, however, the 1981 females were significantly taller than either of the two previous samples.

One factor which affects the short end of the female distribution is the stature limitation for entry into the Air Force. Prior to June 1976, the minimum stature for enlistment was 58 inches for women and 60 inches for men. In order to eliminate the double standard, the minimum stature was changed to 60 inches for both men and women. The 60 inch minimum does not affect the male stature distribution, because few males are shorter than 60 inches (first percentile is about 63 inches). For the stature distribution for females, this makes some difference, since the minimum stature change from 58 to 60 inches occurred between the 1968 and 1981 surveys The difference, if one exists, is not as dramatic as one might think. For the 1968 females, 60 inches is a 5th percentile value, meaning 5 percent of the females were at or below that value. For the 1981 female sample, about 3.3 percent are at or below 60 inches. This difference, about 1.7 percent could be due to the old 58 inch minimum height standard. This may not be the cause, however, because for the 1952 survey of female Basic Trainees, 3.3 percent were at or below 60 inches, the same fraction observed in the 1981 female sample. Apparently, the Air Force is generous with waivers for female stature, because the 1981 sample had females as short as 56 inches, or 4 inches below the standard. Data from all three female surveys show some individuals below the then current standard, so apparently it is not rigidly or consistently enforced.

The question now arises regarding the significance of differences in the female samples found in Figure 7. Are the older samples significantly shorter because of the 58-inch minimum? To answer this, the samples were truncated at the same minimum value (60 inches) and the comparison tests repeated. The means were affected so slightly that none of the differences was eliminated or shrank to an insignificant level.

These data offer compelling evidence that a general growing trend in the population of military recruits is continuing. There is also evidence that the 1968 Survey of Air Force Women may underestimate the stature of the current Air Force women.

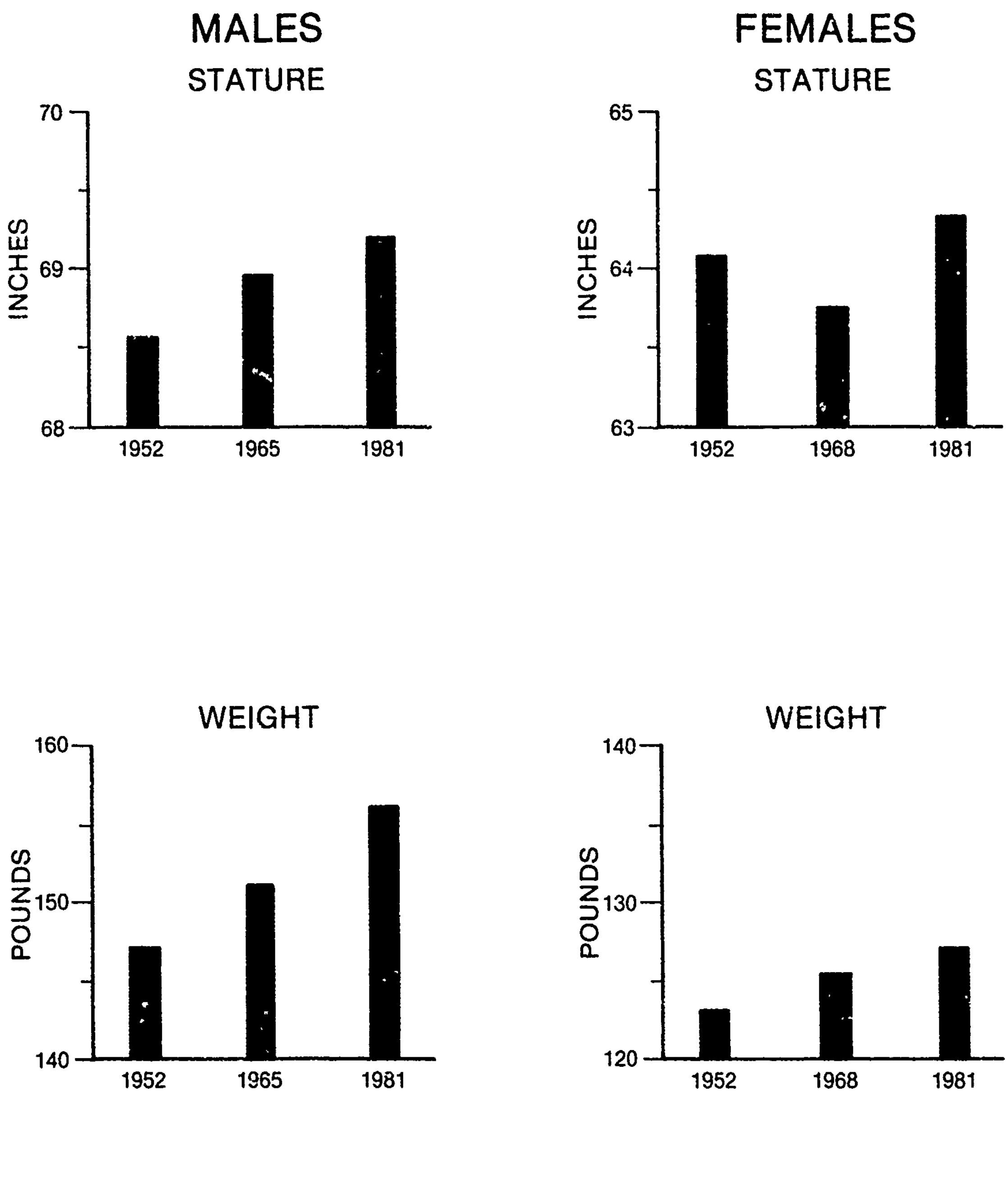


FIGURE 7. GROWTH TREND IN POPULATION MEANS

CONCLUSIONS AND RECOMMENDATIONS

This report has described test procedures which are safe, feasible, and useful for physical strength testing as part of selection or classification of personnel for physically demanding jobs. Comparing these data with design specifications for military equipment indicates that the current standards may be too restrictive. Because weight lift test procedures differ from on-the-job manual materials handling tasks, more research is required to establish predictive relationships between test performance and job performance. In accomplishing any physically demanding job, learned techniques may increase the effective strength of workers. Therefore, some incumbents should be tested and their scores used to validate the relationships established in the laboratory.

RECOMMENDATIONS FOR SAFE WEIGHT LIFT TESTING

Dynamic weight lift testing can and has been safely performed. The procedures which have evolved during the last few years have an excellent record. Various factors which are believed to minimize risk are as follows:

- Weight lifting equipment should be similar to the weight lift machines used in this study, where the weights and handle move only in a vertical direction. Barbells or handles attached to steel cables are unstable and permit lateral twisting of the spine and loss of balance. Overtravel range above the minimum acceptable lift height as well as shock absorbers above and below weights are required.

- Stable footing must be provided. If standard, sturdy shoes are not worn, then subjects should be tested without shoes. Encumbering clothing, such as jackets or coats, should not be worn during testing.

- Test criteria should be a fixed absolute value rather than a value relative to the subject, such as the height of the test subject. Relative criteria may encourage the subject to stoop while lifting, thus placing the subject in an undesirable lifting orientation.

- The initial weight lifted should be low — 20 to 40 pounds. Weights in this range are within the capability of almost everyone. Starting at a low weight encourages subject to accomplish the lift in one smooth motion, without pausing.

- The increments should be small. Ten-pound increments are recommended as a good compromise which will avoid both the potential for overexertion represented by large weight increments and the potential for fatigue caused by a lengthy test period required for the lifting of many slowly-increasing weights.

- The upper limit need not exceed the largest job-related lifting requirement or 160 pounds, whichever is less. Only 10 percent or fewer subjects can lift above 160 pounds, and it is unlikely that any assignment test would want to eliminate more than 90 percent of the applicants.

- The starting handle position should be one to two feet above the standing surface. If the handle is lower, the knees may be a serious obstruction. If the handle is too high, subjects will try to squat to get their shoulder under it prior to lifting.

- The body orientation prior to lifting should be (a) arms straight at the elbow, (b) knees bent to get trunk as erect as possible, and (c) head aligned with trunk. There should be no jerk when lifting.

- If subject pauses during lift, a strength limit has been reached, and the test should be terminated.

- Subjects should fill out a medical history questionnaire. If any suspicious physical conditions are identified, a full physical examination should precede testing. Subjects over 50 years of age or pregnant should have a physical prior to testing.

- Subjects should have the option of taking a minimum rating (associated with the lightest duty category) in lieu of taking the lifting test. The test should always be voluntary.

- All sources of overmotivation should be minimized. Testing should be done in private and the results kept confidential. Even the subject should not be informed of test results on the same day of the test, or at least, not at the test station.

- The subject should be allowed to stop the test at any time. The subject should not be informed of the criteria prior to or during the test.
- Multiple attempts at any single weight level should not be allowed.

Endurance tests involving holding submaximum weights are safe. The discomfort associated with endurance testing causes some subjects to quit before they become fatigued. Endurance tests involving repeated lifting of submaximum weights are believed to be safe, but less practical, because of the long testing time. A greater incidence of muscle soreness will occur with endurance tests involving repetition.

RECOMMENDATION FOR TASK-RELATED RESEARCH

Weight lifting, as performed in tests such as those described in this report, has been shown to be correlated with certain weight lifting tasks performed on the job. There are, of course, important differences. On the job, the weight is free and unrestrained. Sometimes objects to be lifted have neither handles nor even a decent handhold. Bulky objects must be lifted from the floor. Here, the knees of the lifter increase the distance to the load. Also, lifting is not an end in itself. One lifts a load to reposition it, to place it elsewhere, to set it on a shelf, to insert it in a rack, or to carry it somewhere.

While these factors cannot be conveniently and safely considered in a test situation, predictive relationships between these factors and weight lift testing can be established in the laboratory. Much of this work remains to be done before meaningful standards can be set for manual materials handling jobs and the weight limits for objects which workers must lift.

RECOMMENDATIONS FOR TESTING INCUMBENTS

The purpose of preemployment strength testing is, of course, to predict a person's ability to perform a physically demanding job. For this reason, testing entry level personnel, as was done in this study, is appropriate. There are other factors which must be investigated, however. The quality and quantity of strength increase due to the physical conditioning of basic training or working at the job itself must be considered. It is actually this performance which we wish to predict by the tests given at the MEPS. This is a difficult factor to quantify for several reasons. First, basic training in the Air Force is not very physically demanding. When the Factor-X test was given to about 4,000 Basic Trainees before and after basic training, no significant change was found.

As stated earlier, the Army basic training produced low but statistically significant increases in strength. The amount of increase in strength due to performing on the job has not been measured. It is recommended that individuals who have been tested at the beginning of basic training be retested after their first year on the job.

RECOMMENDATIONS FOR DESIGN OF MANUAL MATERIALS HANDLING TASKS AND EQUIPMENT STANDARDS

Data on physical capabilities provide the means to establish meaningful limits for the design of military equipment and the design or redesign of the jobs themselves.

Jobs in the military are routinely modified to meet changes in mission and weapon systems. Jobs may be merged, split, eliminated, or started from scratch. Knowing the demands of individual tasks and the capabilities of workers will allow those responsible for modifying jobs additional insight into the consequences of their actions with regard to the pool of qualified personnel.

Similarly, human engineering standards, such as MIL-STD 1472 which defines weight limits for equipment items and resistance limits for manual controls, can be expanded and improved. Too often, design criteria are based on data gathered in a laboratory setting which represents an ideal or best case condition. The actual job environment rarely corresponds to laboratory tests. For this reason, performance data on actual or simulated work tasks need to be gathered and compared with the test performance data.

Finally, a policy decision will be required concerning the interaction of physical strength standards and the design of jobs. If the workers in a particular job specialty have above average physical capabilities, it would be more cost effective and efficient to design equipment and jobs to those superior capabilities. The consequence of this action, however, is to make these physical standards permanent and to reduce the flexibility for combining jobs. Since human engineering design standards are approved by all the services, modification of these standards to accommodate a restricted subpopulation would require all services to have the same definitions for physical standards.

APPENDIX I

FACTOR-X TEST PROCEDURE
BRIEFING FOR MALE AND FEMALE APPLICANTS

Gentlemen/Ladies, the next step in your examination is to test your physical strength. This test is a requirement for enlistment in the Army and Air Force to assure that you are not placed into a job or skill which might require strength beyond your capability. You should attempt to raise the maximum amount of weight possible as you would then qualify for the greatest number of skills.

You will be required to lift the bar *twice*, once with 40 pounds of weight and then with 70 pounds of weight. Before you lift the bar the correct lifting method will be demonstrated. The key points to remember are these:

1. Grasp the handle to lift the weight overhanded.

2. Take a deep breath and hold it while you are lifting.

3. Start with your arms straight at the elbow.

4. Bend your knees slightly and keep your back as erect as possible.

5. Lift the handle as smoothly and as rapidly as comfortable for you; do not try to jerk the handle at the beginning of the lift.

6. Lower the weights slowly and resume normal breathing.

If any of you have a history of back injury, back strain, recurrent shoulder dislocations, or any other condition that you think could affect you in lifting this weight, please step forward and I will refer you to the Chief Medical Officer to determine if you should be tested.

Are there any questions? Now, observe the demonstration. With the 40-pound weight, you only need to raise it to elbow height. The second part of your test is to lift the 70-pound weight to the mark shown on this rail (six feet). Again, take a deep breath, bend your knees slightly and keep your back as erect as possible, and lift as rapidly as is comfortable for you. Once you have the weight at the mark, lower it slowly and resume normal breathing.

(Each applicant proceeds to test at the 40-pound level. At conclusion, have each person who lifted the 40-pound weight perform the 70-pound lift. Applicants unable to lift the 40 pound weight to elbow height will attempt a lift of 20-pounds. The 20-pound weight will be lifted to elbow height.)

APPENDIX II

DATA FORM for Research Program

Items in this block are to be completed by the person reviewing the SF88 and SF 93.

1. Subject's Name ______________________________

2. SSAN ______________________________

3. Height ______________ Feet ______________ I

4. Weight ______________ Pounds

5. Date of Birth Month ________ Day ________ Year ________

6. Sex Circle: Male Female

7. Factor-X Score Circle: 1 2 3

8. AFSC ______________________________

9. Information on STD Form 93 and STD Form 88 indicate recruit should be exempt from Lifting Test. YES ☐ NO ☐

One of the following blocks is to be completed by the Test Conductor.

Incremental Lift ☐ Pounds to six feet

☐ Pounds to elbow height

Weight Holding ☐ : ☐

Min : Seconds

PRIVACY ACT STATEMENT

Authority: 5USC Sec 301, AFR 35-2 & EO 9397. DISCLOSURE: Completion of the forms, including SSAN is mandatory. Failure to provide complete information will detract from the Air Force's capability to fulfill the following purposes. PRINCIPAL PURPOSE: Development of screening procedures and corresponding job requirements for physical strength and stamina. ROUTINE USES: Personnel and occupational research, job redesign and development of training programs.

APPENDIX III

NARRATIVE FOR THE AUDIO/VISUAL INSTRUCTIONS FOR THE SUBJECTS

(Slide 1) We have asked you to come here to participate in a program to improve the Factor-X test. (Slide 2) This is the weight lifting test you took when you had the physical examination prior to joining the Air Force.

The tests we are conducting today use similar weight lifting machines.

(Slide 3) There are many different jobs in the Air Force, and they have a very broad range of physical demand from very light to very heavy. The purpose of the Factor-X test is to match the physical capabilities of the airman with the physical demands of the job. Unfortunately, the test needs some improvement, and that's where you can help us today.

(Slide 4) Some of you may be thinking, "they don't want to test me because I am not very strong." This is not the case. Eventually, everyone coming into the Air Force will take one or both of these tests.

(Slide 5) We have carefully defined our tests to be safe, letting you be the only judge of how much exertion to apply. However, some of you may have certain medical conditions or old injuries which could be a problem, so if you have a history of any problems described in the consent form, you may not be allowed to take the test.

(Slide 6) We are studying two new lifting tests: one involves measuring weight lift capability, and the other involves holding a weight to measure endurance.

You will only be asked to take one of these tests today, not both. When you entered the room, you were divided into two groups. Those sitting on the LEFT will take the Incremental Weight Lifting Test. Those sitting on the RIGHT will take the Weight Holding Test. You will now get instruction in both tests, but pay attention to the test you will take.

(Slide 7) Those sitting on the left side of the room will take the Incremental Weight Lift Strength Test. The purpose of this test is to measure how much weight you can lift to a height of 6 feet and elbow height.

(Slide 8) Stand on the carpeted area of the weight machine with your feet about six inches apart. (Slide 9) stoop down and grasp the handles. If the position feels awkward, change your foot position and try again.

(Slide 10) Grasp the handles so that your hands are on top of the handles Take a medium breath and hold it during the entire lifting and lowering of the weight.

Start with your arms straight at the elbow, knees bent so that your back is as erect as possible. When you begin the lift, straighten up your body, then lift with your legs.

Do not jerk the handles, but lift as rapidly and comfortably as possible.

(Slide 11) First you will lift a medium weight to six feet. When the white stripe on the handgrip assembly matches the white stripe on the upright, the handles are at 6 feet. It is all right to raise the handles higher than 6 feet.

(Slide 12a) Avoid curving in toward the machine, as shown here. (Slide 12b) Instead, try to keep your head level and body straight.

After each lift, the weight will be increased, and you will try again. You cannot see the weights, and we will not tell you how much weight you lifted. This is not a contest. If you are unable to raise any weight to six feet, the test conductor will ask you to stop. If you feel that you might overexert yourself if you try to lift a heavier weight, just say "I want to stop."

(Slide 13) If you lifted the weight higher than your elbow on the last try, you will be asked to keep lifting heavier weights as high as your elbow until you can't lift the weight that high or you feel you might overexert yourself if you lifted a heavier weight.

(Slide 14) Those sitting on the right side of the room will take the Weight Holding Test. This test is to measure how long you can hold a weight at elbow height.

(Slide 15) First, your elbow height will be marked on the machine.

(Slide 16a) In this test, you grasp the handles underhanded.

As with the other test, assume a position with your feet about six inches apart, knees bent, arms straight, back as erect as possible.

Adjust your feet if necessary to get a more comfortable position.

(Slide 16b) First, for practice, you will lift a 40 pound weight to elbow height and immediately lower it to the starting position. Take a medium breath and hold it while lifting.

(Slide 17) You will then lift a 70 pound weight to elbow height and hold it there as long as possible. Breathe slowly while holding the weight.

(Slide 18) Keep the white pointer in the range of the orange elbow height marker. Dropping below it will signal the end of the test.

(Slide 19) Your TI will not be present during the testing. Neither the TI nor any one at Lackland AFB will be allowed to see your individual information regarding this test. How much or little you do on the tests will not affect your classification or future with the Air Force in any way.

We hope every qualified person will take the test. But your participation today is voluntary. You do not have to take the test if you don't want to.

(Slide 20) The Test Instructor will now answer any questions you may have. Thank you for your cooperation.

APPENDIX IV

SUBJECT CONSENT FORM FOR THE INCREMENTAL WEIGHT LIFT TEST

CONSENT FORM

I, ____, having full capacity to consent, do hereby volunteer to participate in a research study entitled: Interim Fix to the X-Factor Testing Procedure under the direction of Capt Richard J. Skandis, M.D. The implications of my voluntary participation; the nature, duration and purpose; the methods and means by which it is to be conducted; and the inconvenience and hazards which may reasonably be expected have been explained to me by the Test Instructor, and are set forth on the reverse side of this agreement, which I have initialed. I have been given an opportunity to ask questions concerning this research project, and any such questions have been answered to my full and complete satisfaction. I understand that I may at any time during the course of this project revoke my consent and withdraw from the project without prejudice; however, I may be required to undergo certain further examinations, if in the opinion of the attending physician, such examinations are necessary for my health and well being.

I FULLY UNDERSTAND THAT I AM MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. MY SIGNATURE INDICATES THAT I HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE.

____

Signature   Date

I have briefed the volunteer and answered questions concerning the research project.

____

Signature of Test Instructor

I was present during the explanation referred to above, as well as the volunteer's opportunity for questions, and hereby witness the signature.

____

Signature of Test Conductor

CONSENT FORM — LIFTING

You are invited to help us design a new Factor-X test procedure. In this experiment we hope to measure the largest amount of weight that you can lift without hurting yourself.

If you decide to do this, you will be asked to work on a weight-lifting machine like those that are used in a gym. You will start at a low weight. Then more weight will be added for each lift until you feel you are lifting as much as you can without taking any chances of hurting yourself. This is not a contest and you will not get any rewards for doing it.

In this test you will be asked to lift the weight handles on the machine six feet above the floor or until your arms are as high as they can go. After that you will be asked to lower the weight back to the starting position. More weight will be added for the next try. We will keep adding more weight until (1) you can't lift it as high as six feet, or (2) you feel you might hurt yourself if you lifted any more.

If you lift the weight higher than your elbow on your last try, you'll be asked to keep lifting heavier weights as high as your elbow until (1) you can't lift any more weight that high, or (2) you feel you might hurt yourself if you lifted any more.

The actual weight-lifting test will not take more than 5 to 10 minutes of your time.

The medical risks involved with this testing are no different from problems that might be caused by using a regular weight machine in a gym. These include the possibilities of muscle or bone injuries, and either getting or aggravating hernias or hemorrhoids. Before doing the test, you will be asked questions about your medical history and problems such as back pain or injuries, broken bones, dislocated joints, muscle aches, arthritis, hernias and hemorrhoids. We will ask you *not* to do the test if (1) you have a hernia now or (2) if you have had hernias or hemorrhoids in the past which were not fixed. Also, if you have had pain or injury to your lower back, we will ask you not to do the test unless you can show us that you've been in a regular exercise program and have had no back problems for the last six months.

You can expect to have some muscle aches, especially in the arms, shoulders, neck and back for 3 or 4 days after the test. The amount of aching will depend on your physical shape before the test.

If it is not done in the right way, weight lifting can cause lower back injuries. Therefore, we ask you to follow the instructions carefully. We want you to ask any questions you might have before you start lifting.

We ask that you use good judgment in deciding how far to go with the weight lifting. This means that we would like you to stop if you feel that you may overexert yourself if you continue.

These tests are for figuring out strength abilities of men and women so that we can better match Air Force men and women with Air Force jobs that require heavy lifting or carrying duties. Whether or not you decide to join this experiment will have no effect on your future relations with the Air Force. Furthermore, the results of the test will not be used for job placement nor will it make a difference in any decisions about your Air Force career placement.

This experiment is part of a series of weight lifting tests. You will not be asked to take part in more than one.

The medical history form you fill out is for informational purposes. It may disqualify you from taking the test for medical reasons, but even if you pass the medical review you still don't have to take the test if you don't want to. If you decide to take part, you can quit any time during the test and this will not be held against you.

Information about you and results of your testing will remain confidential. Your name will not be given out without your written permission. Statistical data collected during the testing program may be published in scientific reports but individuals will not be identified.

If you have any questions, we expect you to ask us. If you have additional questions later, we will be happy to answer them.

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP, IF YOU REQUEST IT.

____

VOLUNTEER'S INITIALS

APPENDIX V

SUBJECT CONSENT FORM FOR THE 70 POUND WEIGHT HOLDING TEST

CONSENT FORM — HOLDING

You are invited to help us design a new Factor-X test procedure. In this experiment we hope to measure the longest possible time you can hold a 70-pound weight as high as your elbow.

A weight lifting machine like those usually found in a gym will be used. In this test you will be asked to raise a 40-pound weight as high as your elbow and then lower it to the starting position. We will then ask you to lift a 70-pound weight to elbow height and hold it there as long as possible. When you feel you can't hold the weight any more, you will lower it to the starting position. We will record the length of time you hold up the 70-pound weight.

This is not a contest and you will receive no rewards for taking part.

The medical risks involved with this testing are no different from problems that might be caused by using a regular weight machine in a gym. These include the possibilities of muscle or bone injuries, and either getting or aggravating hernias or hemorrhoids. Before doing the test, you will be asked questions about your medical history and problems such as back pain or injuries, broken bones, dislocated joints, muscle aches, arthritis, hernias and hemorrhoids. We will ask you *not* to do the test if (1) you have a hernia now or (2) if you have had hernias or hemorrhoids in the past which were not fixed. Also, if you have had pain or injury to your lower back, we will ask you not to do the test unless you can show us that you've been in a regular exercise program and have had not back problems for the last six months.

You can expect to have some muscle aches, especially in the arms, shoulders, neck and back for 3 or 4 days after the test. The amount of aching will depend on your physical shape before the test.

If it is not done in the right way, weight lifting can cause lower back injuries. Therefore we ask you to follow the instructions carefully. We want you to ask any questions you might have before you start lifting.

We ask that you use good judgment in deciding how far to go with the weight lifting. This means that we would like you to stop when you feel tired and not to go beyond your reasonable limits.

These tests are for figuring our strength abilities of men and women so that we can better match Air Force men and women with Air Force jobs that require heavy lifting or carrying duties. Whether or not you decide to join this experiment will have no effect on your future relations with the Air Force. Furthermore, the results of the test will not be used for job placement nor will it make a difference in any decisions about your Air Force career placement.

This experiment is part of a series of weight lifting tests. You will not be asked to take part in more than one.

The medical history form you fill out is for informational purposes. It may disqualify you from taking the test for medical reasons, but even if you pass the medical review you still don't have to take the test if you don't want to. If you decide to take part, you can quit any time during the test and this will not be held against you.

Information about you and results of your testing will remain confidential. Your name will not be given out without your written permission. Statistical data collected during the testing program may be published in scientific reports but individuals will not be identified.

If you have any questions, we expect you to ask us. If you have additional questions later, we will be happy to answer them.

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP, IF YOU REQUEST IT.

____

VOLUNTEER'S INITIALS

APPENDIX VI

SUPPLEMENTAL MEDICAL HISTORY CHECK SHEET

The following items will be completed by the Test Instructor prior to witnessing consent form:

	YES	NO
1. Information of STD Form 93 and STD Form 88 indicate subject should be exempt from Lifting Test. (See Data Form)	☐	☐

2. Has the subject ever had—	YES	NO
a. back injury	☐	☐
b. hernia	☐	☐
c. chronic back pain	☐	☐
d. hemorrhoids	☐	☐
e. arthritis	☐	☐
3. During last 6 months, has subject had—		
a. any back pain	☐	☐
b. any joint dislocation	☐	☐
4. During last 2 years, has subject had—		
a. any broken bones	☐	☐

5. AFEES Test Y______ N______

Subject's Initials ______________

Completion of this form does not obligate subject to participate in this study.

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