AD A118659

20000727283

Reproduced From
Best Available Copy

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NATICK/TR-82/011

2. GOVT ACCESSION NO.: AD-A118 659

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): VOLUME I. EFFECTS OF GENDER AND LOAD ON COMBATIVE MOVEMENT PERFORMANCE

5. TYPE OF REPORT & PERIOD COVERED: Final Report for Period October 1, 1979 to August 31, 1981

6. PERFORMING ORG. REPORT NUMBER: IPL-237

7. AUTHOR(s):
Richard C. Nelson, Ph.D.
Philip E. Martin, M.S.

8. CONTRACT OR GRANT NUMBER(s): DAAK60-79-C-0131

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Biomechanics Laboratory
The Pennsylvania State University
University Park, Pennsylvania 16802

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 6.2, 1L162723AH98AJ005

11. CONTROLLING OFFICE NAME AND ADDRESS:
US Army Natick Research and Development Laboratories
ATTN: DRDNA-ICCH
Natick, Massachusetts 01760

12. REPORT DATE: February 1982

13. NUMBER OF PAGES: 67

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report):

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

loads	load carrying	military personnel
males	anthropometry	exercise
females	combative movement	field tests
frame-pack systems	performance	field operations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study was conducted to determine the effects of loads worn or carried by men and women on their movement capabilities. Fourteen women and sixteen men performed seven tests under each of the following load conditions: Load 1 - baseline (shorts, t-shirt, sneakers); Load 2 - fighting gear (utility shirt and trousers, boots, ALICE fighting gear); Load 3 - combat gear (Load 2 plus PASGT helmet, PASGT armor vest, simulated M16 rifle); Load 4 - combat gear and 20-lb backpack load (Load 3 plus ALICE LC-2 frame and ALICE pack with 20-lb load);

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Section 20(cont'd.)

Load 5 - combat gear and 35-lb backpack load (Load 4 plus an additional 15-lb in backpack). The men were also tested under a sixth load condition: Load 6 - combat gear and 50-lb backpack load (Load 4 plus an additional 30-lb in backpack). The seven performance tests consisted of 10- and 25-yard sprints, an agility run, a standing long jump, reaction movements to the left and right, and a ladder climb. All were timed tests with the exception of the standing long jump in which the score was the horizontal displacement of the subject. Analyses of the performance data indicated that the scores of the men were significantly superior to those of the women on all tasks. The effects of load condition varied somewhat across tasks, but, on five of the tests, there were significant differences among all load conditions, except Loads 4 and 5, with performance levels decreasing as load was increased. Statistical analyses were also performed to determine the relationship of task performance to body height, weight, and percent body fat, as well as the day-to-day and trial-to-trial reliability of each performance measure. Further analyses were included on the relationships of load condition and task performance to body weight and lean body weight.

Preface

This is the first of four volumes comprising the final report of research performed under Contract Number DAAK60-79-C-0131 with the Individual Protection Laboratory, US Army Natick Research and Development Laboratories, Natick, Massachusetts. The work was formulated and directed by Drs. Carolyn K. Bensel and Richard F. Johnson, Human Factors Group, Individual Protection Laboratory. Dr. Bensel was the contract monitor and Dr. Johnson was the alternate.

The authors wish to express their appreciation to persons who provided special assistance during the conduct of the experimental part of this project. Joe Johnstonbaugh, John Palmgren, Brenda Palmgren, and Thomas Eby, technical staff members contributed their creative talents to this investigation. Mrs. Jo Cleary and Catherine Lendrim provided valuable administrative and secretarial assistance. Special thanks are extended to In-Sik Shin, Fujio Hashimoto and Yasuo Ikegami for their help with data collection and analysis. Thanks also to Per Balke for completing the skinfold measurements.

The cooperation of Col. Arthur Dervais, Professor of Military Science, is gratefully acknowledged. He was instrumental in the recruitment of the R.O.T.C. students and supported the project through issuance of military equipment and provision of the Armory facility for conducting the performance and walking tests. Finally, the authors wish to thank the young men and women for their dedicated service as subjects.

Accession For
NTIS GRA&I ☒
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

DTIC COPY INSPECTED 2

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

Effects of Gender and Load on Combative Movement Performance

Introduction

This is the first of four studies on the biomechanics of load carrying behavior being carried out in the Biomechanics Laboratory at The Pennsylvania State University under the direction and sponsorship of the Army Natick Laboratories. In addition to the work reported here, other aspects being investigated include a comparison of different frame-pack systems for male and female subjects during easy standing, jumping and walking. The stimulus for this research results from modifications and innovations in the design of pack systems and the expanded role of women in field operations necessitating investigation of their load carrying capabilities.

This study was designed to determine the effects of gender and load on combative movement performance. Fourteen women and sixteen men, who were representative of the military population in height and weight, served as subjects for this phase of the project. All subjects were students at Penn State University and were participants in the Army ROTC program. In all, there were six different measurement or testing sessions. During Session 1, anthropometric measures were taken. Sessions 2 through 6 involved performance testing under several different load conditions.

Experimental Design

Session 1. The first session served as an orientation for the subjects who were provided details of the performance testing and in which they completed information and informed consent forms. In addition, selected anthropometric measures were taken on each subject and the weights of their utility clothes, boots, and sneakers were determined and recorded. Direct measurements were made of body height, body weight, and selected skinfold measures. From these values, a calculation of the percentage of body fat was made.

Calculation of the percent of body fat, made from a knowledge of body weight, surface area, and skinfold thickness measurements, was performed using the formula of Allen, et al.[1] Body surface area was derived indirectly from height and weight measurements according to Dubois and Dubois.[2]

[1] Allen, T.H., M.T. Peng, K.P. Chen, T.F. Huang, and H.S. Fang. Prediction of total adiposity from skinfolds and the curvilinear relationship between external and internal adiposity. Metabolism 5:346-352, 1956.

[2] Dubois, D. and E.F. Dubois. Clinical calorimetry: A formula to estimate the appropriate surface area if height and weight be known. Arch. Intern. Med. 17:863, 1916.

Skinfold thickness was measured at ten body sites on the right side of the body. The included sites were: cheek, chin, chest, side, waist, abdomen, upper arm, back, knee and calf. The anatomical locations of each skinfold site were described by Skerlj, *et al.*[3] with the exception that the cheek site selected was below the temple, between the tip of the right ear and the nose. Three consecutive measurements were taken at each site using Lange skinfold calipers with the average recorded as skinfold thickness. The method suggested by Behnke and Wilmore[4] was used for taking skinfold measurements with all readings taken to the nearest millimeter. The following formulae were used in the calculation of body fat and percent of body fat:

$$T = \frac{\text{Sum of 10 skinfolds} - 40}{20}$$

$$\text{S.A.} = \text{Ht.}^{0.725} \times \text{Wt.}^{0.425} \times 0.007184$$

$$\text{Body Fat} = \text{Body Wt.} \times \sqrt{\frac{T \times \text{S.A.} \times 0.739}{\text{Body Wt.}}} - 0.0003 \times 0.7$$

$$\%\ \text{Fat} = \frac{\text{Body Fat}}{\text{Body Wt.}} \times 100$$

In addition to the above mentioned measures and calculations, a waist back measurement was taken on each subject. This measurement was defined as the distance from the projection of the seventh cervical vertebra at the base of the neck to a line connecting the crests of the ilia at the level of the waist. Although this measure was not used in the analysis of data for this project, it was thought that it would provide valuable information for future use when consideration is given to frame lengths used in pack design. The measure was taken using a steel tape and followed the contour of the back.

Each subject was also fitted for an armor vest, fighting gear, and helmet in order to save time later during the performance testing.

[3]Skerlj, B., J. Brozek, and E.E. Hunt, Jr. Subcutaneous fat and age changes in body build and body form in women. Am. J. Phys. Anthrop. 11:577-600, 1953.

[4]Behnke, A.R. and J.H. Wilmore. Evaluation and regulation of Body Build and Composition. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1974.

Sessions 2 through 6. The performance testing of the male and female subjects was conducted in Sessions 2 through 6. Each subject completed seven different performance tests under several different load conditions. The female subjects completed the tests under five load conditions while the men completed the tests under six load conditions. The performance tests and load conditions will be described in more detail later. The test schedule was arranged to minimize the effects of fatigue and to also provide for the replication of selected load conditions so that day-to-day reliability of performance could be evaluated. The following table summarizes the testing schedule:

Table 1

Summary of Test Sessions

Session	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6
1	Anthropometric measures					
2	X	X				
3		X	X			
4			X	X		
5					X	
6	(Men only)					X

As shown in Table 1, the subjects performed under two load conditions in each of the first three performance testing sessions in which the lower levels of load were carried. The final two testing sessions involved only one load each since it was feared that the high levels of load carried during these sessions, and subsequent fatigue produced by these high levels, might adversely affect the level of performance. Session 4 included both Loads 3 and 4 and was clearly the most difficult session for the subjects.

Performance Tests

The test movements performed by the male and female subjects were selected on the basis of previous experience in load carrying studies. They represented a variety of human motions and responses which simulate some of the conditions under which a soldier must perform in a combat situation. The physical capabilities tested included sprinting, movement over a short distance in response to a visual signal, successive changes in direction (agility), rapid vertical climbing, and jumping for distance. All experimental movements were performed in the Armory Building on Campus, which provided sufficient space for the performance of the tests. A schematic diagram of the test area is presented in Figure 1.

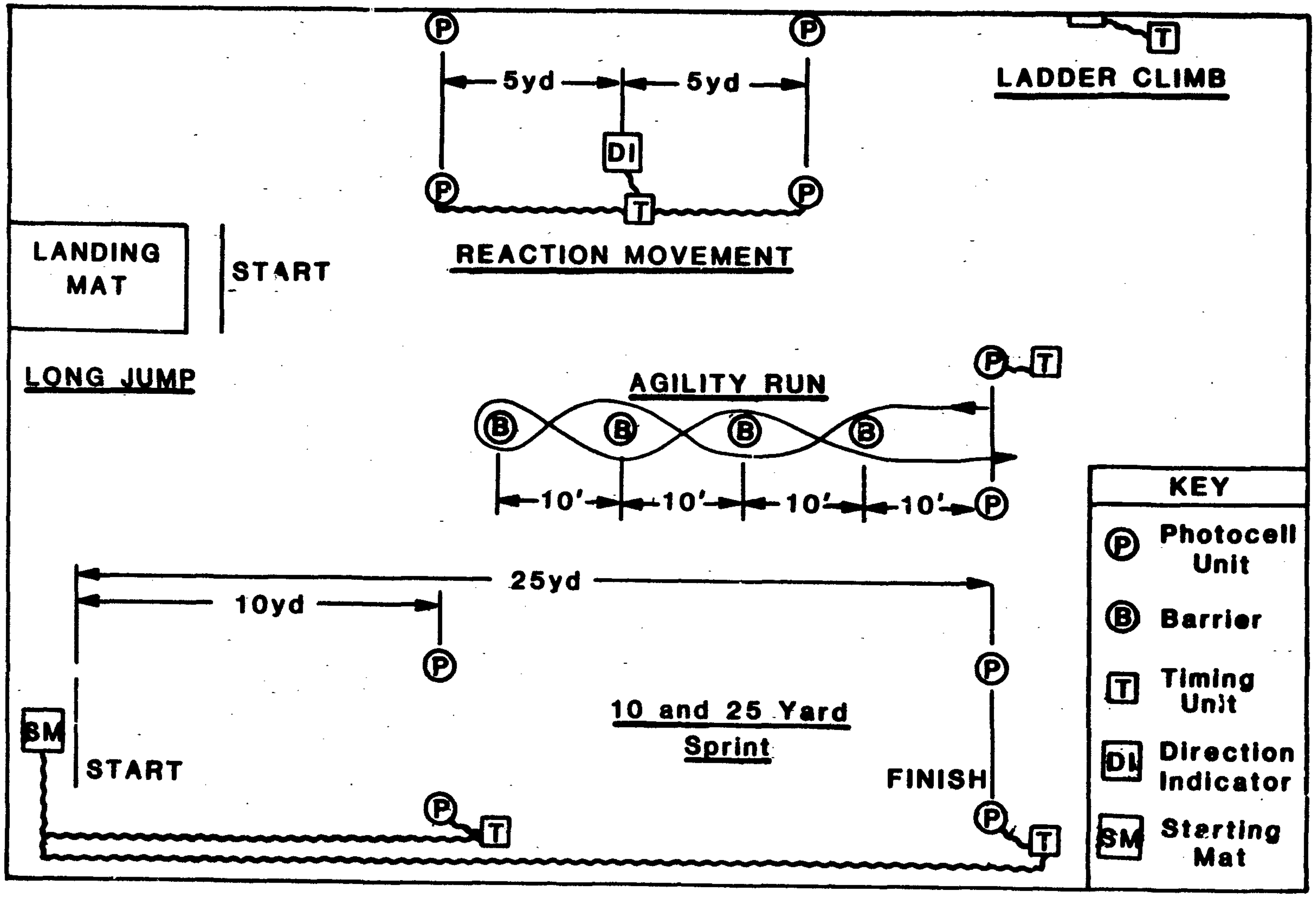

Figure 1. Schematic of Test Area Showing Location of Performance Tests.

Ten- and twenty-five yard sprints. Subjects completed a timed 25-yard sprint starting from a standing position. An intermediate time at the 10-yard point was also recorded to evaluate the early phase of the sprint test. These two recorded times from a single trial were treated as two separate performance tests. One foot was placed directly behind a starting line while the other foot, the back foot, held down a foot switch. The subjects were allowed to start upon their own volition. The release of the foot switch upon starting initiated two electronic Dekan timing units. Photocells were placed ten yards (9.1m) and twenty-five yards (22.8m) from the starting line. The breaking of the beam at each of the photocell locations acted to stop the timing units so that times at the 10- and 25-yard distances for each sprint trial could be measured and recorded. Each subject performed three trials.

Agility run. A series of four padded circular obstacles 106.7cm high with a diameter of 20.3cm were placed 304.8cm apart with the first located 304.8cm from the starting line. Each subject initiated a trial upon their own volition. As the subjects left the starting line they broke a beam of a photocell system which started an electronic timing unit. All subjects were instructed to pass on the right side of the first obstacle, to weave through the remaining obstacles passing around the last obstacle, and then to weave through the obstacles on the return to the starting area. The timer was stopped when the subjects broke the beam of the photocell system a second time as they passed through the starting area on the return. Three trials were completed by each subject.

Standing long jump. Each subject performed three trials of a standing long jump for maximum horizontal distance. The subjects performed the test using a one-legged takeoff technique in which the feet were in a staggered position such that one foot was placed directly behind a starting line and the other foot was placed behind the line at a distance freely chosen by the subject. The subject initiated the jump by swinging the back foot forward and pushing off with the front foot. The length of the jump, measured using a steel tape, was the distance between the starting line and the position of the toe of the foot which landed the shorter distance from the starting line. The subjects were allowed to select which foot they preferred to have forward at the start.

Reaction movement tests. The reaction movement tests required the subject to respond to a directional light signal by turning either to the right or left and sprinting 4.6m. Each performed six trials, three to the right and three to the left which constituted two performance tests. The subject initially assumed a ready position straddling a line which was midway between two sets of photocells 9.1m apart, and facing the directional light signal unit. For each trial, the subject was given a "ready" command shortly before the light stimulus was presented. An electronic timer was started when the light came on and stopped as the subject broke the beam of the photocell system on either the right or left side. To avoid anticipation, the length of time between the ready signal and the light stimulus was varied. In addition, the right and left trials were randomly mixed.

Ladder climb. A vertical ladder 5.5m high with circular rungs 2.5 cm in diameter 57.2cm wide and spaced 30.5cm apart was constructed for this test. Subjects assumed a starting position in which the left foot was placed on the first rung of the ladder and the right foot held down a foot switch. The subjects were allowed to position their hands in a manner which was comfortable to them. They started upon their own volition and by releasing the foot switch triggered an electronic timing unit. They were instructed to climb up the ladder as quickly as possible with an alternating step technique, which assured that foot contact was made with each rung. The ladder was instrumented with a photocell system such that the timer was stopped when the subject's foot broke a beam at the level of the ninth rung (304.8cm-level). Three trials were performed.

Load Conditions

The subjects completed the seven performance tests under a variety of load conditions so that the influence of load on physical performance could be examined. A careful selection of loads was made to cover a wide range of typical military loads. In addition, a minimal load condition was added to provide baseline performance data for comparative purposes. The other loads represented systematic increases. In all there were six different loads. The male subjects performed under all six load conditions while the female subjects performed under the five lower loads. The following summarizes the six load conditions used in the testing:

Load 1 served as the baseline condition. Subjects wore shorts, socks, t-shirt, and sneakers. These items averaged .59kg and .77kg for women and men, respectively.

Load 2 was considered the fighting gear condition. The subjects wore underwear, socks, utility shirt and trousers, boots, and the standard, ALICE fighting gear which included a water-filled canteen with cover, intrenching tool with carrier, and two small arms ammo cases containing 1.75 kg sandbags. The means were 9.07 kg and 9.41 kg for women and men, respectively.

Load 3 was designated the combat gear condition. The subjects wore a PASGT helmet and armor vest and carried a simulated M-16 rifle in addition to those items included in Load 2. The mean values for women and men were 16.95 kg and 17.59 kg, respectively.

Load 4 included all items from Load 3 plus the ALICE LC-2 frame and a large ALICE field pack containing a 20-pound (9.1-kg) load. This load consisted of a sleeping bag, mattress, waterproof clothes bag, poncho, socks and undershirt. The loads for women and men were 29.29 kg and 29.93 kg, respectively.

Load 5 included all items from Load 4 plus an additional weight of 15 pounds (6.8 kg) placed in the pack. The extra load consisted of three, 5-pound (2.3-kg) barbell disks. The load values for women and men were 36.09 kg and 36.73 kg, respectively.

Load 6 was carried by the men only and included all items from Load 4 plus 30 additional pounds (13.6 kg) in the form of three, 10-pound (4.5-kg) disks placed in the pack. The load was 43.53 kg.

The weights of the individual components and their combinations used for the experimental loads are presented in Tables 2 and 3. The clothing and equipment used in this study are described in Appendix A.

Table 2

Component Weights and Load Condition Combinations for Men (N=16)

Item	Weight (kg)	Load Condition 1	2	3	4	5	6
Sneakers, Shorts & T-shirt	.77	X					
Shorts, T-shirt, Utility Shirt & Trousers	1.04		X	X	X	X	X
PASGT Helmet	1.40			X	X	X	X
Combat Boots	1.72		X	X	X	X	X
M-16 Rubber Rifle	3.17			X	X	X	X
PASGT Armor Vest	3.61			X	X	X	X
ALICE Fighting Gear	6.65		X	X	X	X	X
ALICE LC-2 Frame & Large Field Pack	12.34				X	X	X
Three, 5-lb Disks	6.80					X	
Three, 10-lb Disks	13.60						X
Total Weight (kg)		.77	9.41	17.59	29.93	36.73	43.53

Table 3

Component Weights and Load Condition Combinations for Women (N=14)

Item	Weight (kg)	Load Condition 1	2	3	4	5	6
Sneakers, Shorts & T-shirt	.59	X					
Shorts, T-shirt, Utility Shirt & Trousers	.98		X	X	X	X	
PASGT Helmet	1.40			X	X	X	
Combat Boots	1.44		X	X	X	X	
M-16 Rubber Rifle	3.17			X	X	X	
PASGT Armor Vest	3.31			X	X	X	
ALICE Fighting Gear	6.65		X	X	X	X	
ALICE LC-2 Frame & Large Field Pack	12.34				X	X	
Three, 5-lb Disks	6.80					X	
Total Weight (kg)		.59	9.07	16.95	29.29	36.09	

The subjects in Figures 2-5 demonstrate the experimental load conditions. Additional weight was added to the pack shown in Figure 4 to create Load Conditions 5 and 6.

Figure 2. Load Condition 1.

Figure 3. Load Condition 2.

Figure 4. Load Condition 3.

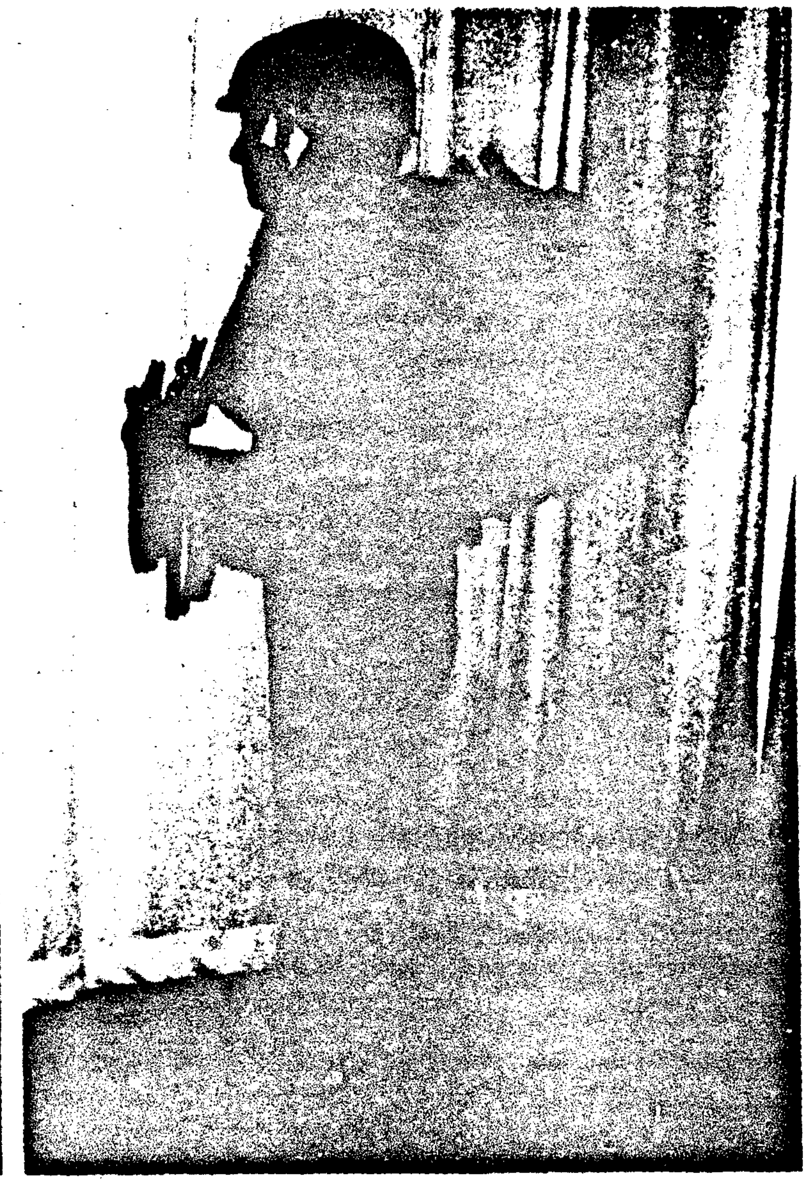

Figure 5. Load Condition 4.

Statistical Procedures

Several statistical procedures were performed on the data during this phase of the project. Initially, it was necessary to compare the heights and weights of the men and women subjects for the experiment with those values reported for the population of male and female Army personnel to determine whether the sample under investigation could be considered representative. An independent t-test was used for this comparison.

The data were statistically analyzed using a series of statistical programs which were available for general use at the University Computation Center. The subprogram t-test of the Statistical Package for the Social Sciences was used to examine the trial-to-trial reliability within a single day and also the day-to-day reliability for the repeated Loads 2 and 3.

The program ANOVR, created by Dr. P.A. Games of the Educational Psychology Department at Penn State University, provided for the analysis of the two-factor design employed in this study. The options of unequal cell size and an alpha level of .05 were selected. Output from the ANOVR programs provided information concerning the homogeneity of variances which was used to conduct post hoc procedures involving the TUKEY Test when significant F-values were found.

Subjects

Sixteen men and fourteen women, all students in the Army R.O.T.C. Program at Penn State University, served as subjects. Their military experience and strong interest in the research made them ideally suited as subjects in this project. Their diligence and high level of motivation assured their best efforts throughout the testing program. The descriptive characteristics and statistical comparisons are presented in Table 4.

Table 4

Physical Characteristics of Subjects

	Men (N=16)		Women (N=14)			
Characteristic	$\bar{X}$	S.D.	$\bar{X}$	S.D.	t	P
Height (cm)	175.2	7.1	165.9	5.4	4.0	<.05
Weight (kg)	69.8	7.2	59.9	9.3	3.3	<.05
Body Fat (Percent)	16.8	3.0	23.4	3.6	5.5	<.05
Waist Back (cm)	47.4	2.5	45.6	2.5	1.7	N.S. (<.10)

These results indicate that the males were significantly greater in height (5.6%), body weight (16.5%); greater in waist back length (4%) (but not significantly different); and significantly lower in body fat (39%) than the females.

Comparison with military personnel. The height and weight data from these subjects were compared with data published on male and female Army populations to assure that a reasonable similarity existed. The men were compared with the results published by White and Churchill.[5] The data for the female comparison were taken from the work of Churchill, Churchill, McConville and White.[6] A simple t-test was used in which a sample mean derived from our subjects was compared with what was considered to be a population mean from the military subjects. The results are presented in the following table.

Table 5

Comparison of Sample Subjects with Military Personnel

	Project Sample			Army Population				
	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	t	P
Men								
Height (cm)	16	175.1	7.1	6682	174.5	6.6	0.37	N.S.
Weight (kg)	16	69.8	7.2	6677	72.2	10.6	1.33	N.S.
Women								
Height (cm)	14	165.9	5.4	1331	163.0	6.5	2.06	N.S.
Weight (kg)	14	59.9	9.3	1331	60.0	8.7	0.06	N.S.

[5] White, R.M., and E. Churchill. The Body Size of Soldiers: US Army Anthropometry - 1966 (Tech. Rep. 72-51-CE). Natick, Mass: US Army Natick Laboratories, pp. 71 and 73, December, 1971.

[6] Churchill, E., T. Churchill, J.T. McConville and R.M. White. Anthropometry of Women in the US Army - 1977: Report No. 2 - The Basic Univariate Statistics (Tech. Rep. NATICK/TR-77/024). Natick, Mass: US Army Natick Research and Development Command, p. 46, June, 1977.

Overall the sample subjects were representative of the military personnel. This was clearly shown for the height of males and weight of females where the means were almost identical. The sample men were somewhat lighter ($\bar{X}$ diff. = 2.4 kg) while the women were slightly taller ($\bar{X}$ diff. = 2.9 cm) than their military counterparts, but these differences were not statistically significant. Based on this analysis, it was concluded that the subjects used in this experiment were very similar to persons serving in the U.S. Army and, thus, strengthened the interpretation of the results derived from the project.

Trial-to-Trial Test Reliability

The experimental design employed made it possible to assess the trial-to-trial reliability within test sessions for all performance tests under all six load conditions. In addition, day-to-day reliability was determined for Load Conditions 2 and 3 since the performance tests for these loads were completely replicated in a second test session. Because these performance tests had not been used previously under the conditions of this experiment, it was essential that a detailed evaluation of test reliability be conducted. The analysis involved application of a dependent t-test to assess mean differences and standard product moment correlation methods.

Trial-to-trial reliability coefficients were calculated for each of the seven performance tests for all six load conditions. Load Conditions 2 and 3 were replicated in two test sessions so it was possible to calculate day-to-day reliability coefficients based on the mean of the three trials within test sessions. In all cases, the data for males and females were treated separately due to the differences in performance which distort the distribution of scores, thereby falsely elevating the correlation values.

A total of six correlation coefficients, three for males and three for females, were calculated for Loads 1, 4 and 5, twelve coefficients for Loads 2 and 3, and three (males only) for Load 6. This resulted in a total of 45 trial-to-trial correlation coefficients for each of the seven performance tests. The between day reliability coefficients totaled 28, two for each performance test for Loads 2 and 3. As a means of presenting an overall evaluation for each test, a graphic method has been selected in which each correlation for men and women is depicted for each load condition.

Ten-yard sprint. The reliability coefficients for this test are presented in Figure 6. It is evident that the female subjects tended to be more reliable than the males with most of the coefficients being above 0.80. The reason for the lower value for the males is not clear. One factor that affects the magnitude of the correlation coefficients is the variability in the data. The standard deviation for female performance was approximately twice as large as that for the males. This relatively low variability for the males may have contributed to the lower correlation coefficients. Overall, the reliability for this test was considered to be acceptable.

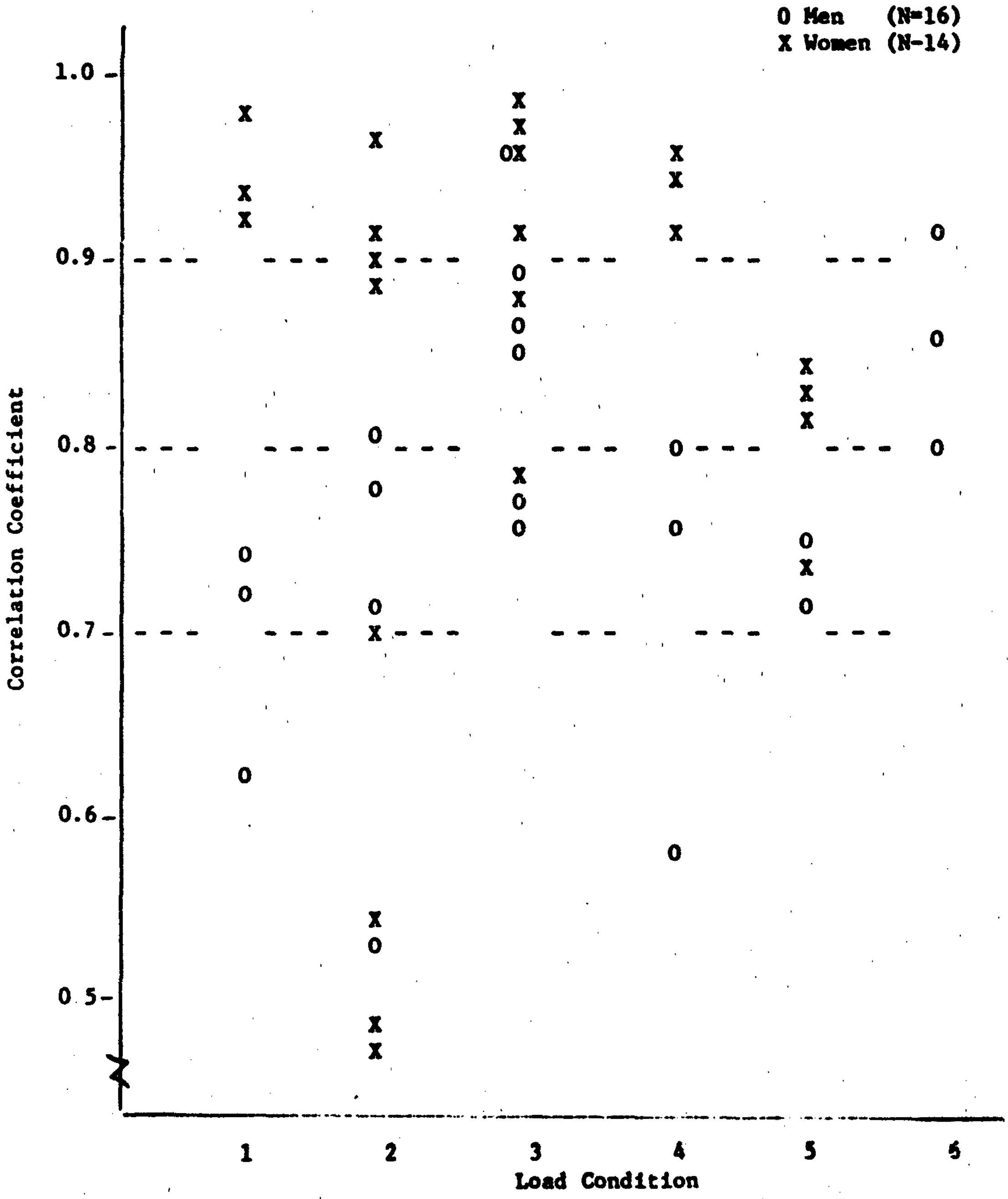

Figure 6. Trial-to-Trial Reliability Coefficients for Men and Women for the Ten-Yard Sprint Under All Load Conditions

Twenty-five yard sprint. The results shown in Figure 7 indicate somewhat higher values for the female subjects and, in general, relatively high reliability coefficients.

Standing long jump. The majority of the coefficients for this test were between 0.75 and 0.95 with similar values for males and females (See Fig. 8).

Reaction movement right and left. The reproducibility of the test performances for these movements was relatively poor, as can be seen in Figures 9 and 10. Again, the female subjects were more consistent than the males. It is possible that these lower coefficients were caused by the anticipation of the subjects as to which light would come on signalling the direction of movement. In any case, the subjects were not able to produce consistent performance from trial to trial. This limitation was offset to some extent by utilizing the mean of all three trials in the statistical analysis of the main effects.

Ladder climb. The performance of the men and women on this test was very similar with respect to test reliabilities. Further, a relatively high degree of consistency was demonstrated for both groups with most coefficients above 0.80 (See Fig. 11).

Agility run. Female performance generally produced high reliability coefficients for this test while overall the performances of both groups were highly reproducible (See Fig. 12).

Mean comparisons. In addition to the examination of correlation coefficients derived from individual trials, comparison of the trial means was conducted using a dependent t-test. This resulted in a total of 315 t-tests of which 34 were statistically significant at the .05 probability level. Of this number, approximately 16 could be attributed to chance due to the large number of t-tests. Furthermore, the comparisons lacked independence since all three means for a given performance test and load were interdependent. Consequently, the actual probability level was above .05, adding further to the number of significant t-ratios. Considering all of these factors, it was concluded that mean performance within trials was reasonably consistent over all performance tests and load conditions.

Day-to-Day Reliability

It was not possible to completely replicate all tests and loads under the same conditions on two separate days due to the excessive subject and experimenter time required. Thus, a detailed day-to-day reliability evaluation was not conducted. A limited analysis was possible for Loads 2 and 3. Load 2 was included in Test Sessions 1 and 2 and Load 3 in Test Sessions 2 and 3. The analysis was based on the mean of three trials for each test for these two loads. Reliability coefficients and day-to-day mean comparisons were made.

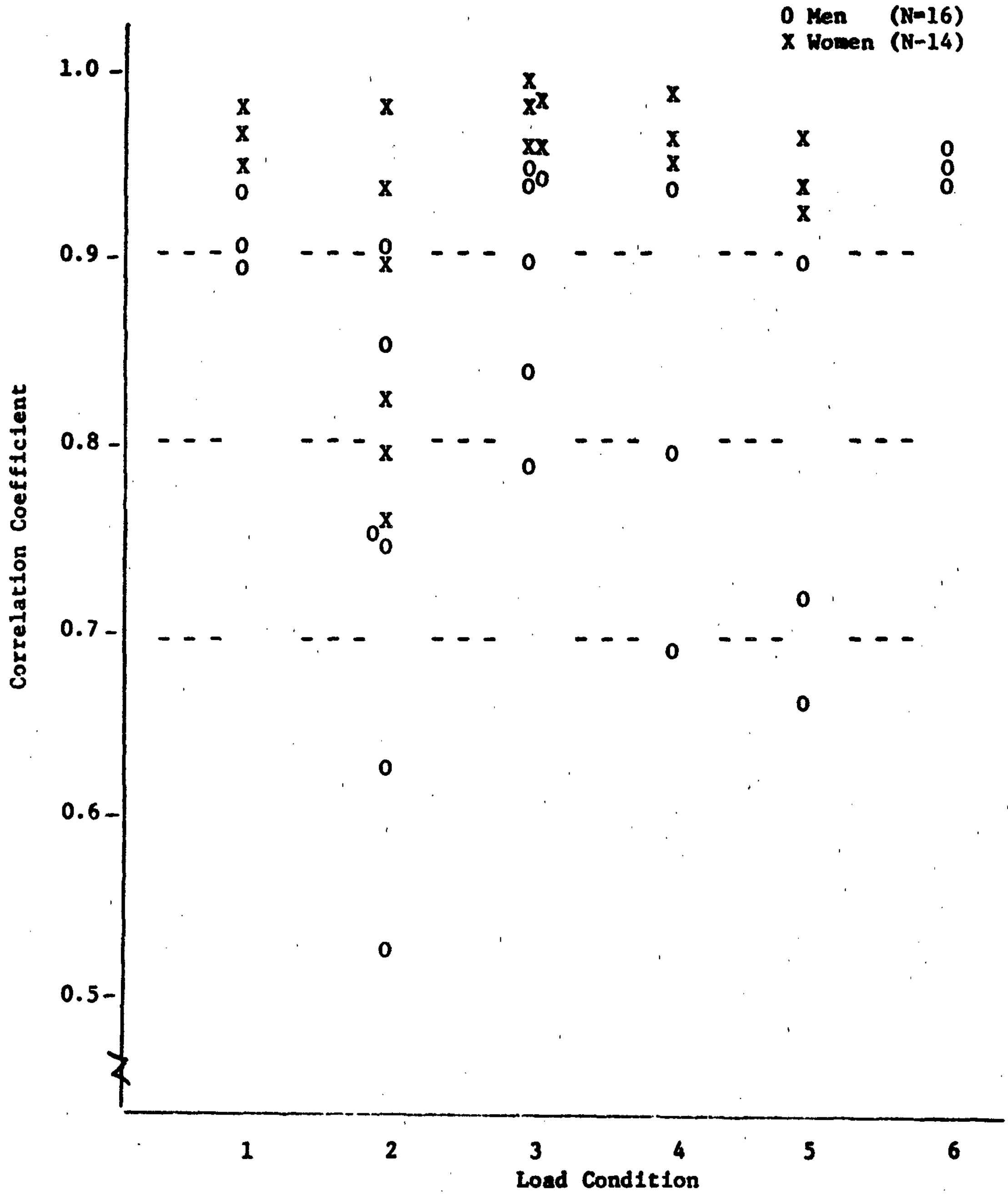

Figure 7. Trial-to-Trial Reliability Coefficients for Men and Women for the 25-Yard Sprint Under All Load Conditions.

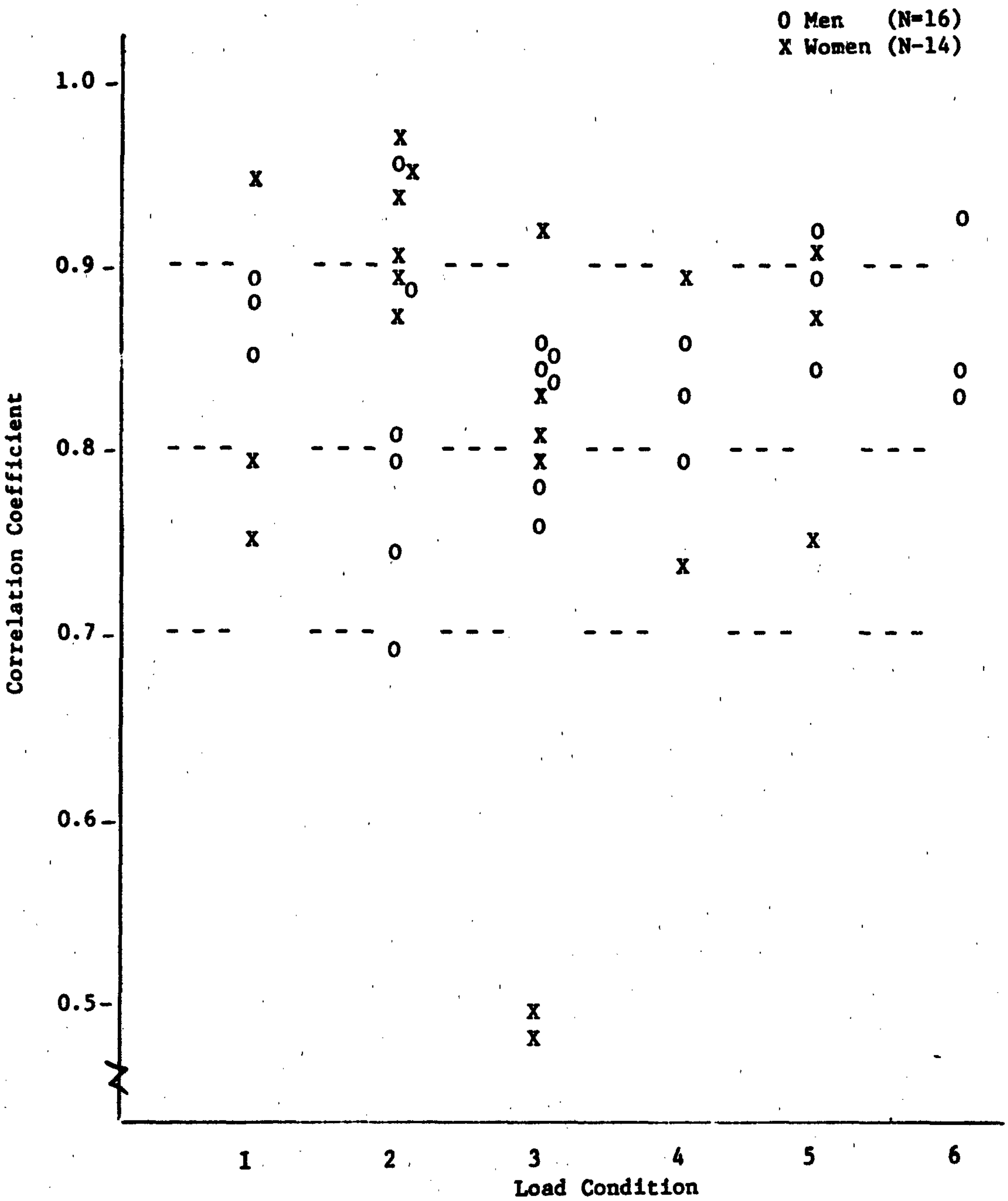

Figure 8. Trial-to-Trial Reliability Coefficients for Men and Women for the Standing Long Jump Under All Load Conditions.

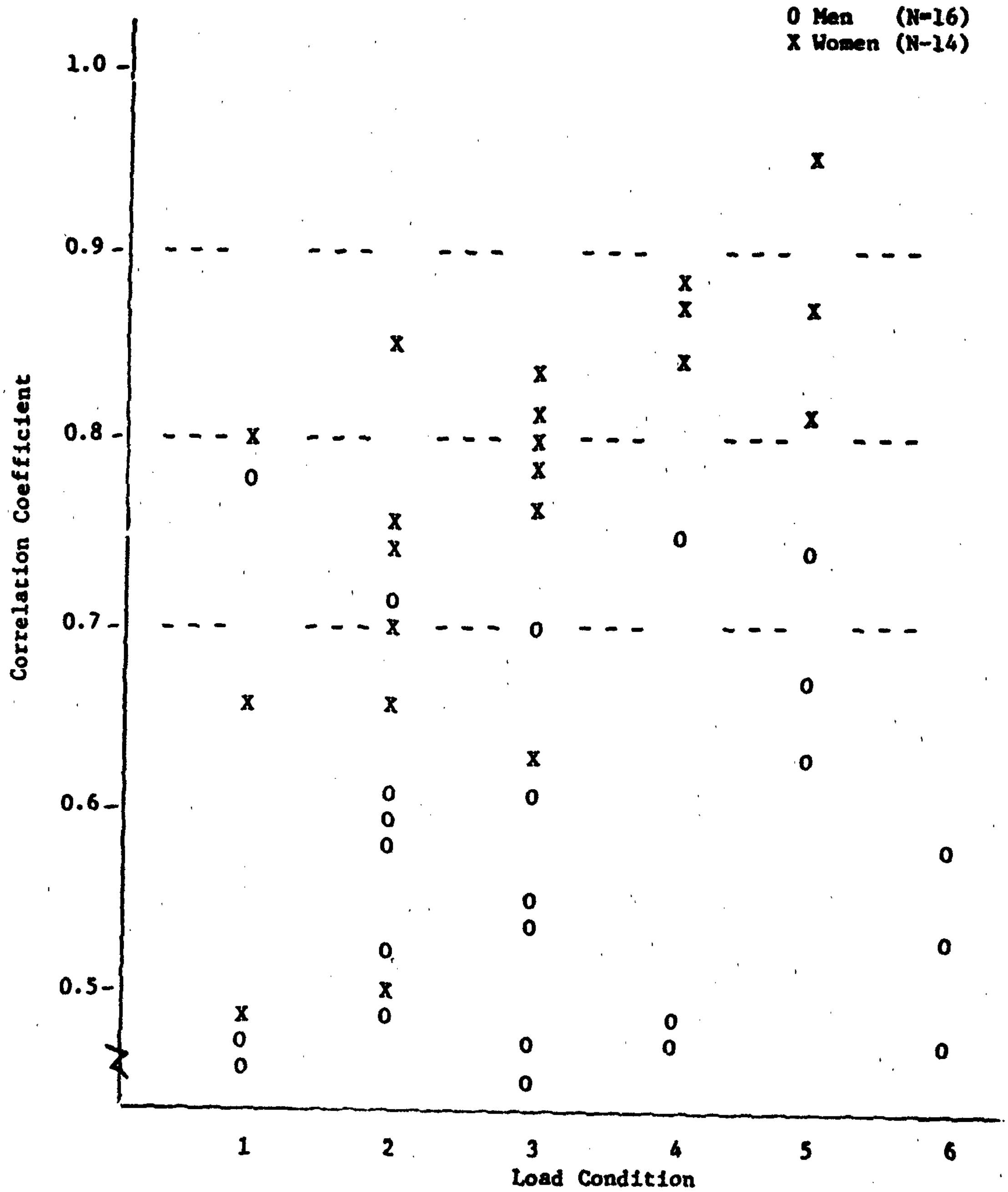

Figure 9. Trial-to-Trial Reliability Coefficients for Men and Women for the Reaction Movement Right Under All Load Conditions.

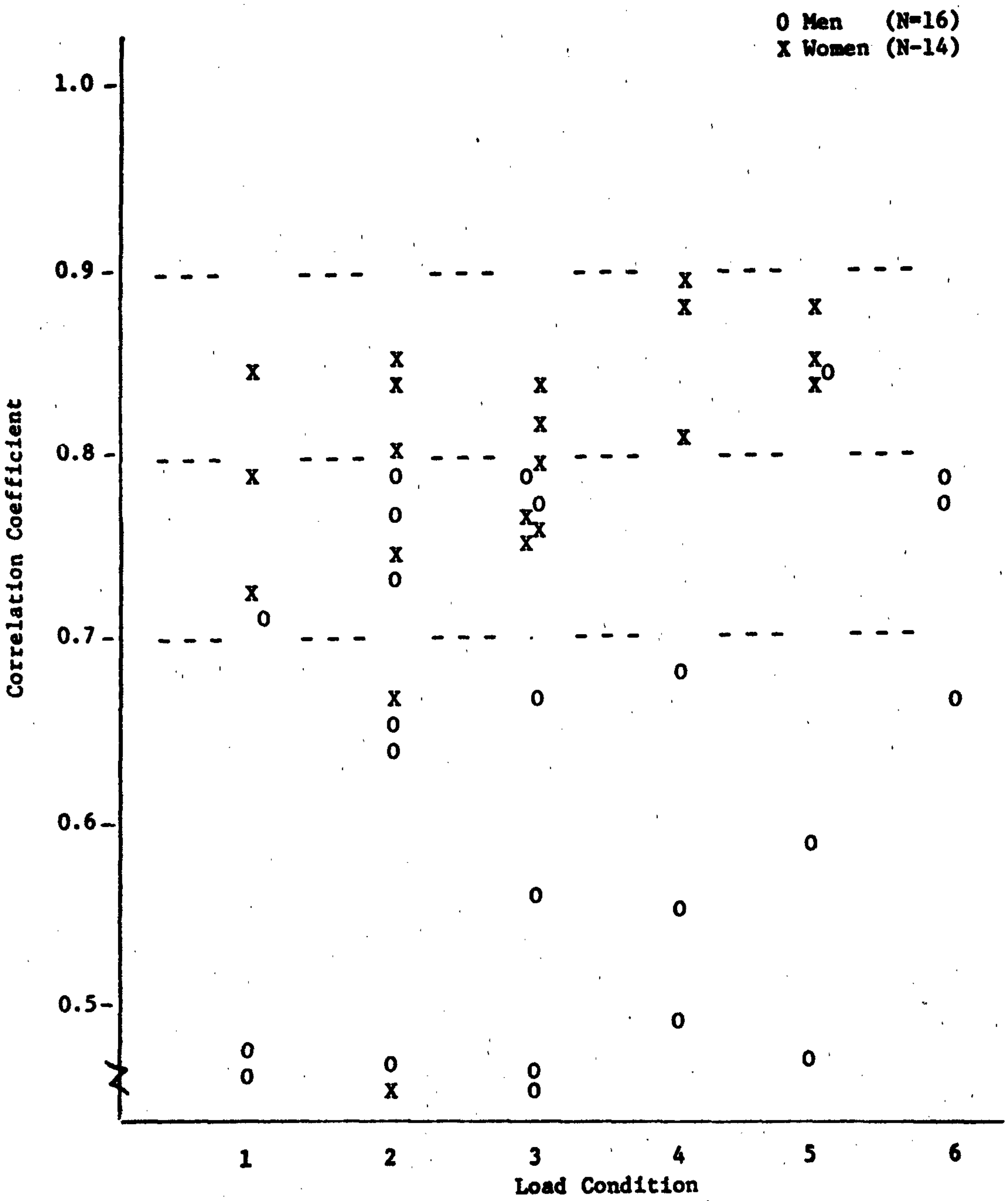

Figure 10. Trial-to-Trial Reliability Coefficients for Men and Women for the Reaction Movement Left Under All Load Conditions.

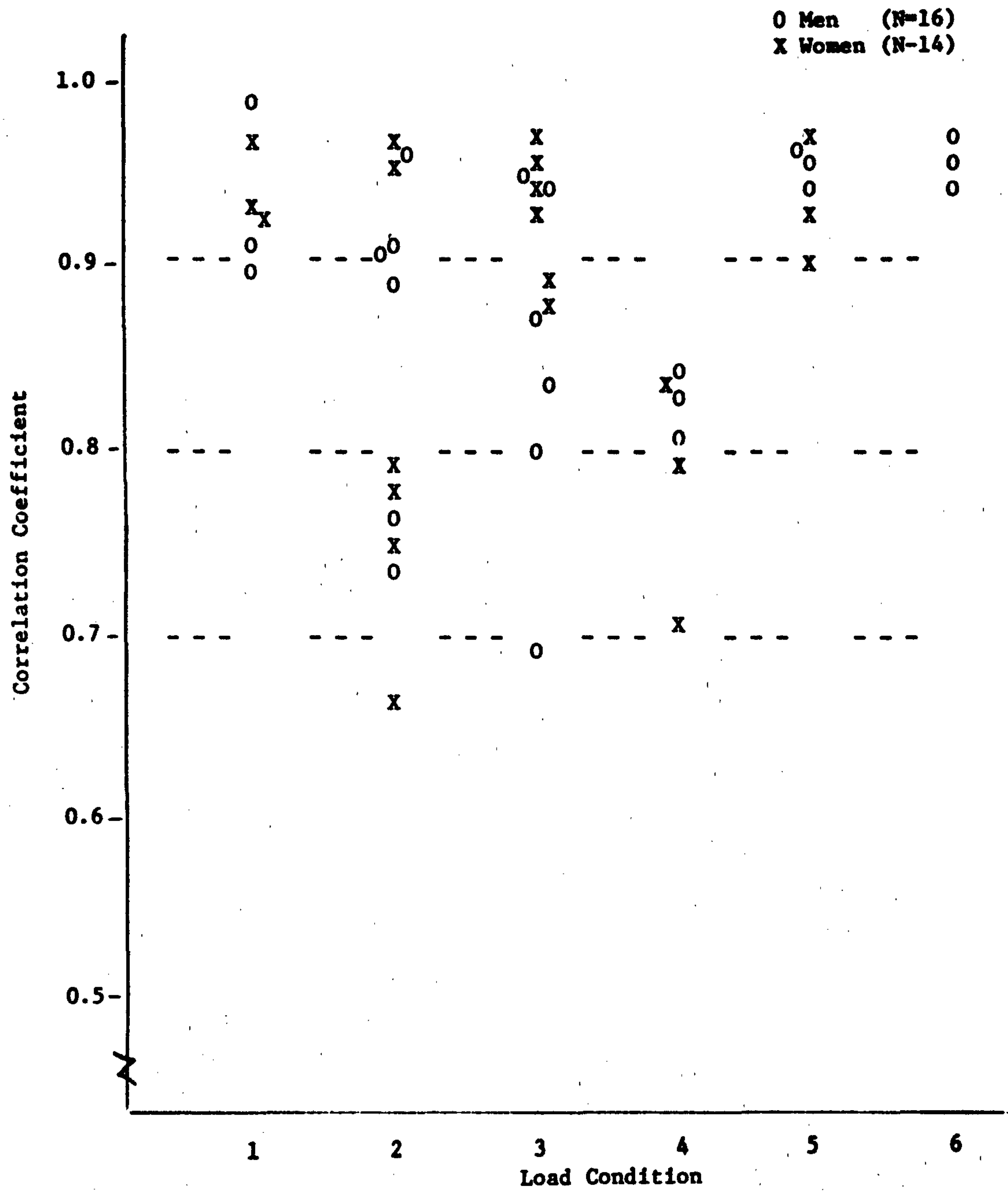

Figure 11. Trial-to-Trial Reliability Coefficients for Men and Women for the Ladder Climb Under All Load Conditions.

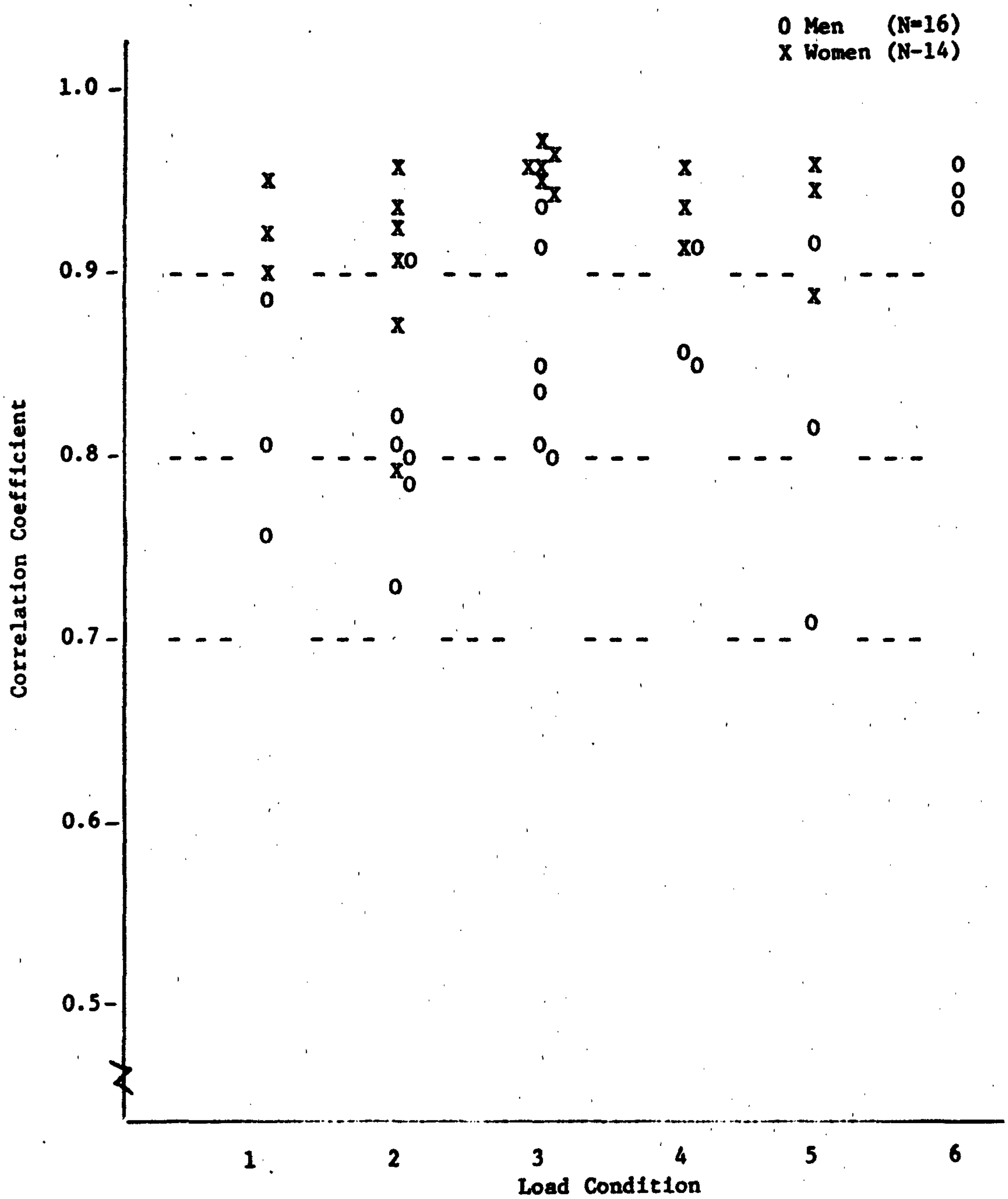

Figure 12. Trial-to-Trial Reliability Coefficients for Men and Women for the Agility Run Under All Load Conditions.

Table 6 contains the reliability coefficients. It is clear that the consistency of subject performance across days for these loads was moderate. Of the 28 coefficients, 9 were below 0.70, while 12 were above 0.80.

Results of the comparisons of mean values revealed better performance on the second day for 26 of the 28 comparisons. Eleven of the t-tests for mean differences were statistically significant at the .05 level.

A number of factors may have influenced these results. The test protocol did not, in fact, provide an exact replication on both test days. For example, the tests under Load 2 for Day 1 were performed following those for Load 1, while for Day 2 they were performed first. In the case of Load Condition 3, it was performed followi[illegible]d 2 in Session 2, but was performed first in Session 3. Furtherm[illegible]ain degree of learning from day to day on the part of so[illegible] the subjects may have occurred. Because of these limitatio[illegible]od of replication, the day-to-day test reliability was somewh[illegible] anticipated. However, this was not considered to be a ser[illegible]ation.

Table 6

Day-to-Day Test Reliability Coefficients for Men (N=16) and Women (N=14)

TEST	LOAD 2 Men	LOAD 2 Women	LOAD 3 Men	LOAD 3 Women
1. 10-Yard Run	0.41	0.60	0.46	0.93
2. 25-Yard Run	0.45	0.63	0.71	0.94
3. Long Jump	0.71	0.74	0.80	0.86
4. R M Right	0.70	0.81	0.54	0.78
5. R M Left	0.50	0.72	0.69	0.61
6. Ladder Climb	0.89	0.87	0.86	0.92
7. Agility Run	0.78	0.81	0.90	0.93

Performance Test Results

A Two-Way Analysis of Variance (ANOVA) test with main effects of gender and load and their interaction was applied to the performance data for each test. The mean of three trials for Loads 1, 4, and 5 and six trials for Loads 2 and 3 were used in the statistical analysis. The results are presented in tabular and graphic form utilizing appropriate mean values. Follow up procedures involving the TUKEY Test were carried out when significant main effects or interactions were obtained. ANOVA summaries are presented in the Appendix.

Ten- and twenty-five yard runs. The results for these tests are presented in Tables 7 and 8, and Figures 13 and 14. The main effects of gender (F's = 107 and 73) and load (F's = 268 and 390) and their interactions (F's = 17 and 27) were all significant with the men performing better than the women. Mean load comparisons for the total group were all significantly different except for Loads 4 and 5 for both tests. Comparison of the load conditions for each sex revealed significant differences for all loads except between Loads 4 and 5 for women on both tests. The significant interaction resulted from the greater decrement in the performance of the women across the load conditions.

Table 7

Gender and Load Means for
10-Yard Sprint (sec)*

		Load Condition					
Sex	N	1	2	3	4	5	Sex $\bar{X}$
Male	16	1.75	1.91	1.98	2.12	2.17	1.99
Female	14	2.07	2.30	2.42	2.71	2.74	2.45
Load $\bar{X}$		1.90	2.09	2.18	2.40	2.44	

*Means not underlined or connected by vertical lines are significantly different (P<.05).

Table 8

Gender and Load Means for
25-Yard Run (sec)

Sex	N	Load Condition 1	2	3	4	5	Sex $\bar{X}$
Male	16	3.57	3.96	4.16	4.51	4.60	4.16
Female	14	4.31	4.93	5.28	5.94	6.04	5.30
Load $\bar{X}$		3.92	4.41	4.68	5.18	5.27	

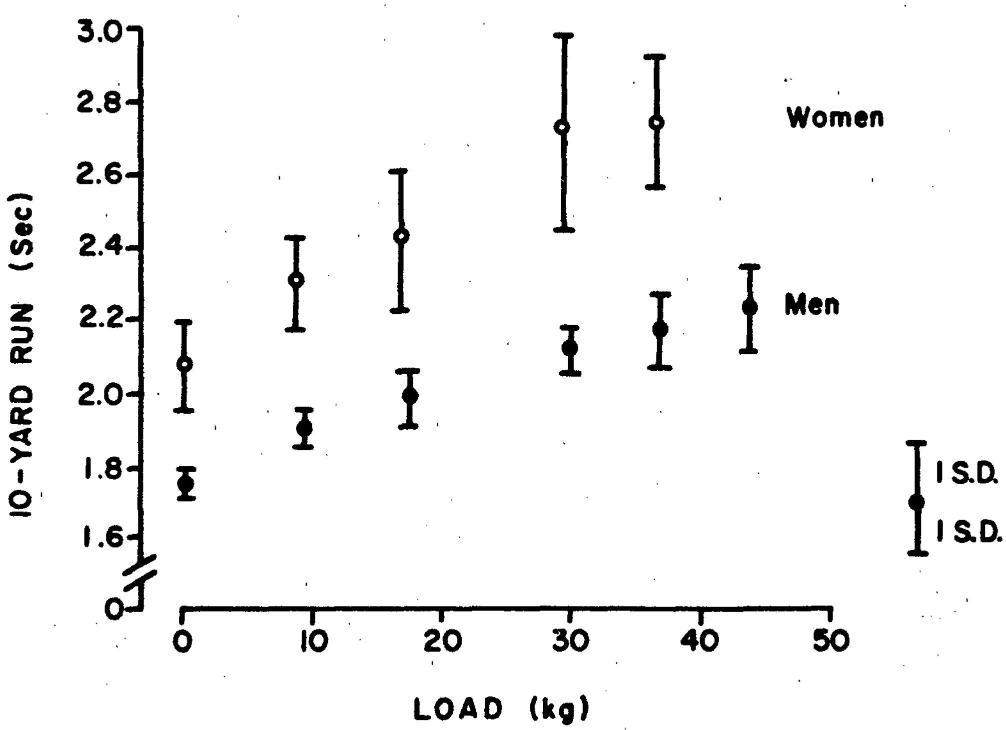

Figure 13. Mean 10-Yard Run Time versus Load Condition.

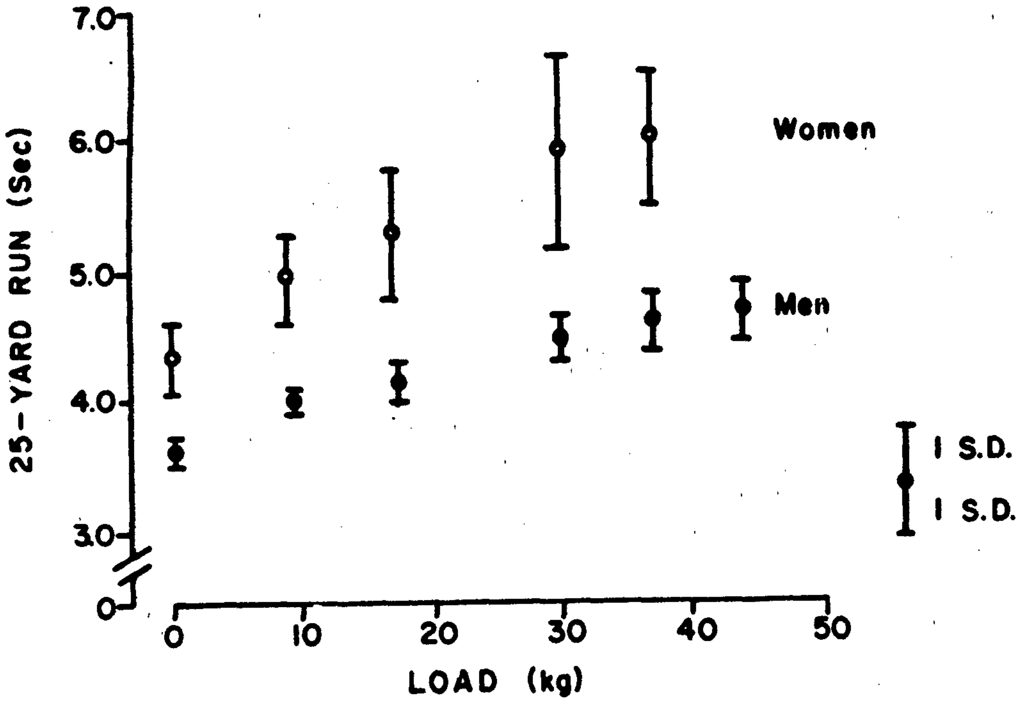

Figure 14. Mean 25-Yard Run Time versus Load Condition.

Long jump. The main effects of gender (F = 121) and load (F = 472) were significant, with all load conditions differing significantly from each other due to a systematic decrease in performance associated with increased load. The men jumped significantly further than the women for all loads. However, the pattern of performance across the loads was similar for men and women as indicated by the non-significant gender and load interaction (F = 1.5). The mean values are presented in Table 9 and shown graphically in Figure 15.

Table 9

Gender and Load Means for
Long Jump (m)

Sex	N	Load Condition 1	2	3	4	5	Sex $\bar{X}$
Male	16	2.47	2.24	2.16	1.89	1.82	2.16
Female	14	1.96	1.72	1.58	1.37	1.31	1.59
Load $\bar{X}$		2.31	2.00	1.89	1.65	1.58	

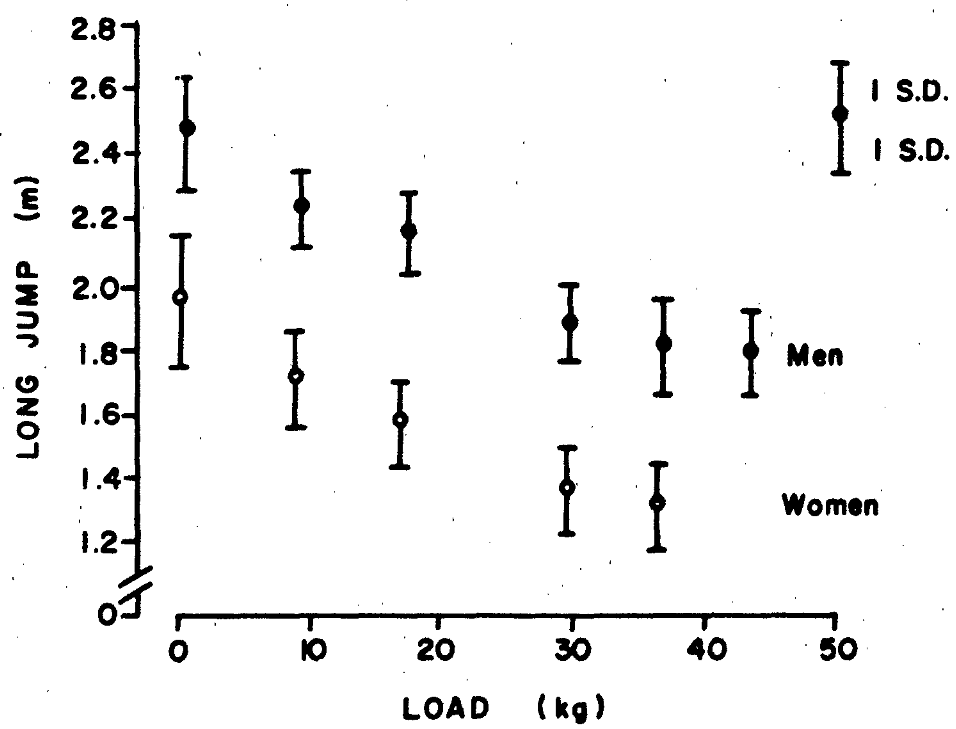

Figure 15. Mean Long Jump Performance versus Load Conditions.

Reaction movement right and left. Tables 10 and 11, and Figures 16 and 17, contain the mean values for these tests. In both cases, male performance was better than female (F's = 90 and 95) and all loads (F's = 126 and 176) differed significantly from each other except 4 and 5. This similarity was also observed for the men and women separately. The gender x load interaction was also significant (F's = 3.2 and 6.5) indicating a differential load effect upon the two groups of subjects. Examination of the mean values indicated a greater reduction in performance of the females as the load increased. It is interesting to note the consistency of the group performance on both tests as the cell and total group means are almost identical. This is somewhat surprising in light of the relatively low reliability associated with these tests.

Table 10

Gender and Load Means for
Reaction Movement Right (sec)

		Load Condition					
Sex	N	1	2	3	4	5	Sex $\bar{X}$
Male	16	1.70	1.76	1.80	1.93	1.95	1.83
Female	14	1.92	2.00	2.09	2.25	2.26	2.11
Load $\bar{X}$		1.80	1.87	1.94	2.08	2.10	

Table 11

Gender and Load Means for
Reaction Movement Left (sec)

		Load Condition					
Sex	N	1	2	3	4	5	Sex $\bar{X}$
Male	16	1.68	1.74	1.78	1.91	1.93	1.81
Female	14	1.88	2.00	2.06	2.23	2.25	2.08
Load $\bar{X}$		1.78	1.86	1.91	2.06	2.08	

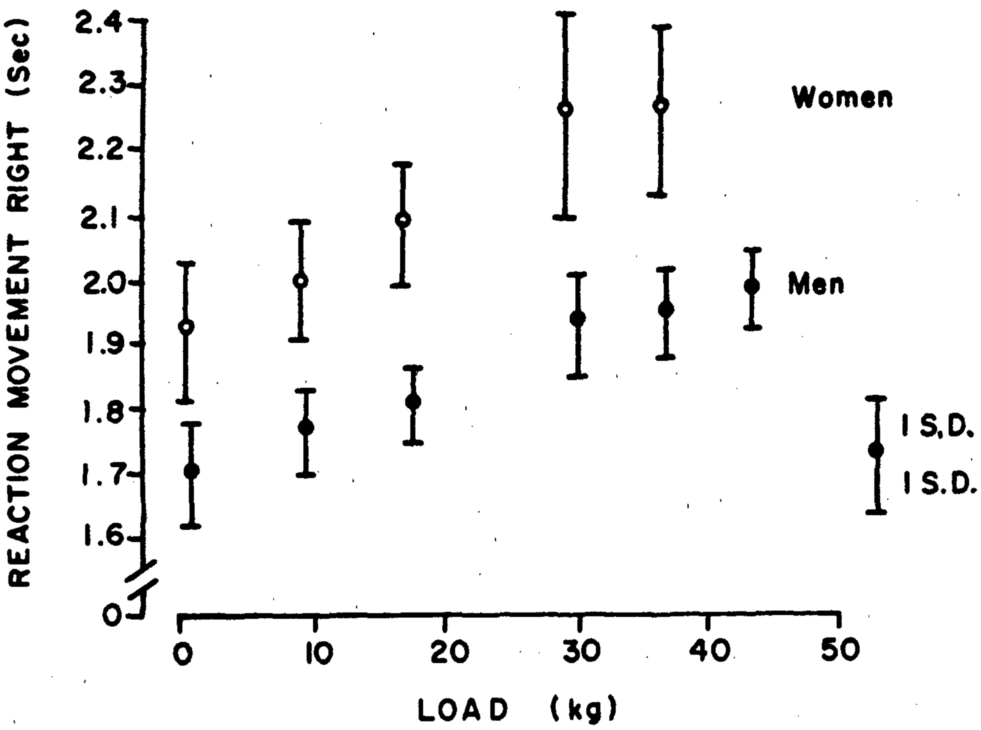

Figure 16. Mean Reaction Movement Right Performance versus Load Condition.

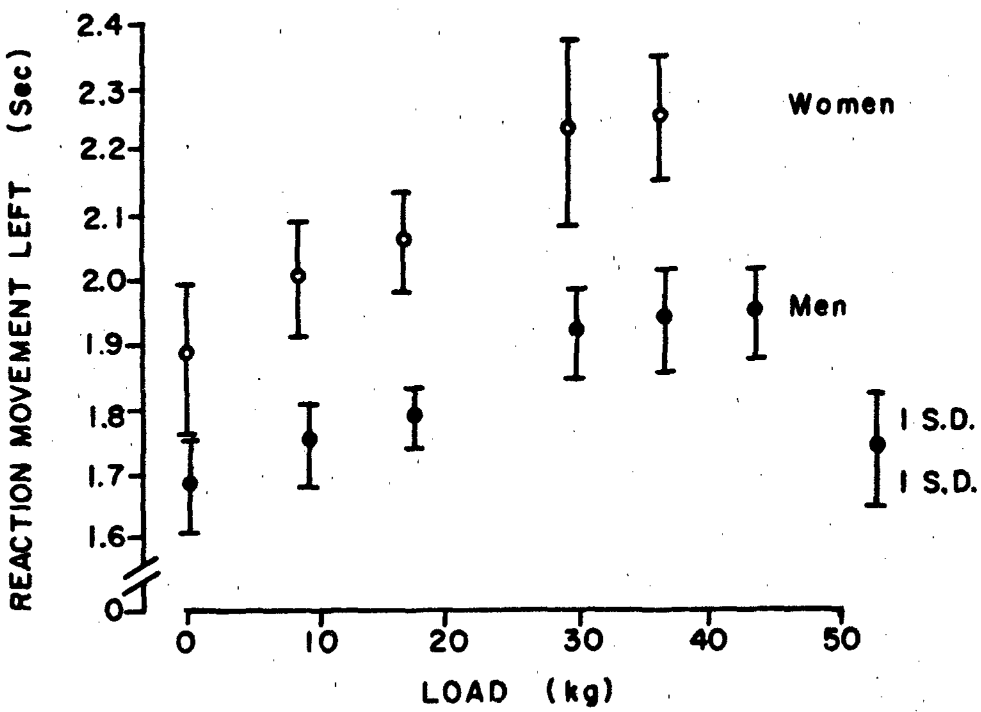

Figure 17. Mean Reaction Movement Left Performance versus Load Condition.

Ladder climb. Although the main effects for gender (F = 60) and load (F = 61) and interactions (F = 28) were all significant, the internal comparisons revealed unexpected results (See Table 12 and Figure 18). Similar non-significantly different performances were noted across the first three loads and Loads 4 and 5. This could, in part, be due to the learning effect since the subjects were somewhat unfamiliar with the ladder climb movement. This result was not anticipated since a decrease in performance would be expected as a result of the increased load.

Table 12

Gender and Load Means for Ladder Climb (sec)

		Load Condition					
Sex	N	1	2	3	4	5	Sex $\bar{X}$
Male	16	2.32	2.24	2.25	2.89	3.22	2.58
Female	14	3.46	3.35	3.66	6.66	7.82	4.99
Load $\bar{X}$		2.85	2.76	2.91	4.65	5.36	

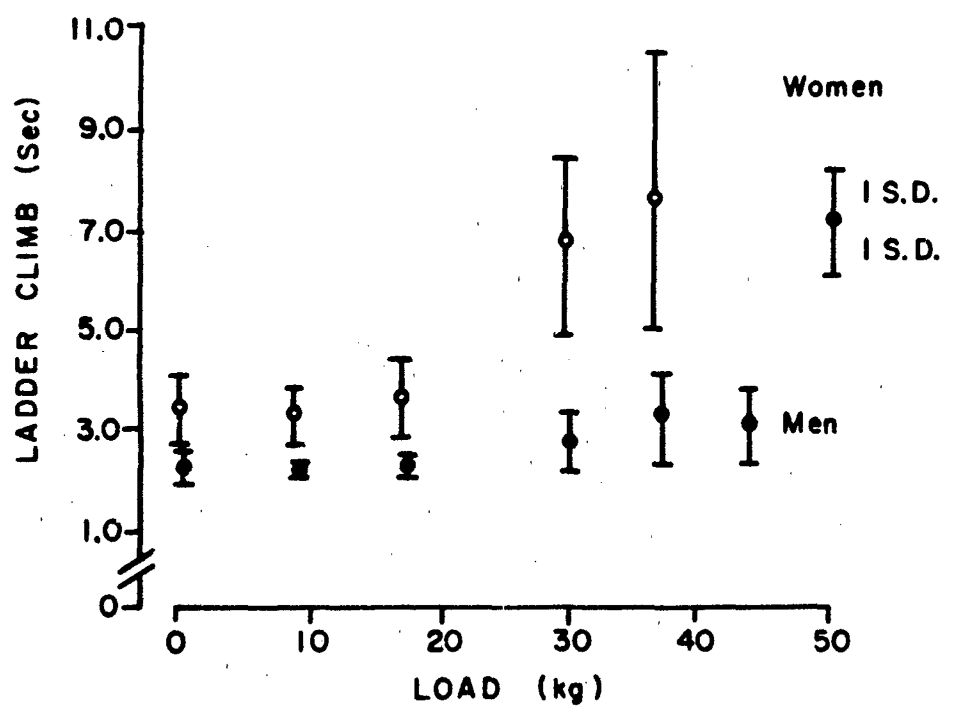

Figure 18. Mean Ladder Climb Performance versus Load Condition.

Agility run. The main effects for gender (F = 74), load (F = 390) and their interaction (F = 27) were significant with males performing significantly better than females. Although the load effect was significant, internal analysis revealed a non-significant difference between Loads 4 and 5 for the total group and also for the men and women separately. This result was somewhat unexpected since it indicated the subjects were able to complete the agility run in the same approximate time under Load 5 in comparison to Load 4 even though an additional 15 pounds (6.8 kg) had been added to the pack (See Table 13 and Figure 19).

Table 13

Gender and Load Means for
Agility Run (sec)

		Load Condition					
Sex	N	1	2	3	4	5	Sex $\bar{X}$
Male	16	6.70	7.20	7.54	8.22	8.28	7.59
Female	14	7.58	8.37	8.90	10.27	10.06	9.04
Load $\bar{X}$		7.22	7.75	8.18	9.17	9.11	

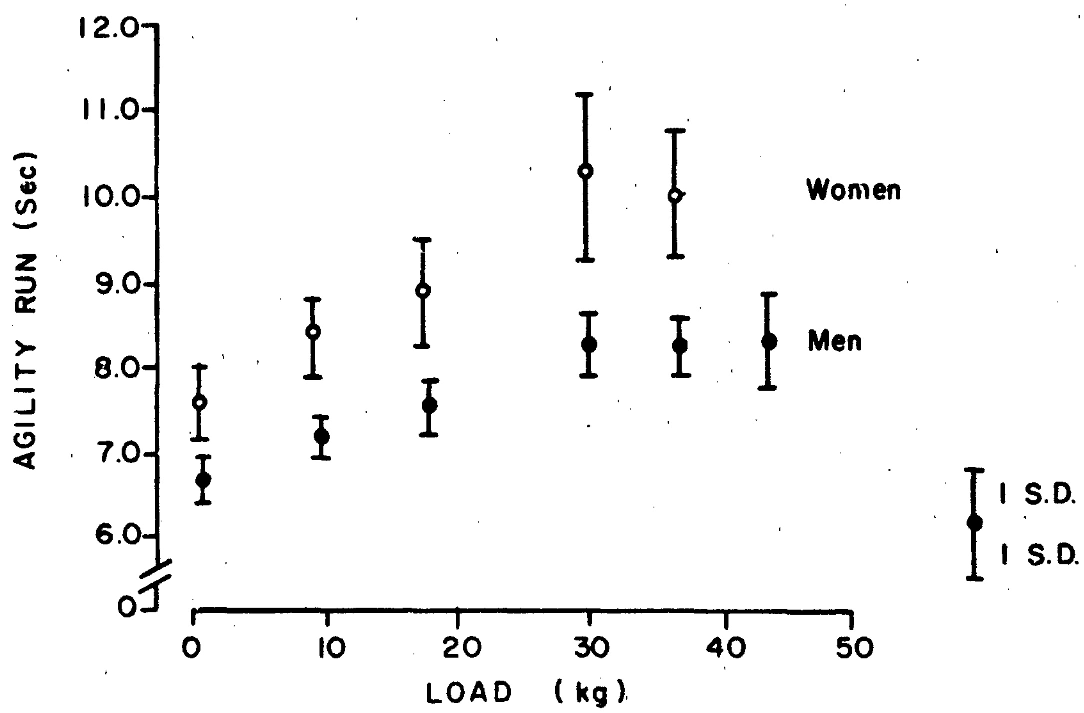

Figure 19. Mean Agility Run Time versus Load Condition.

Relative Performance of Men and Women

The results showed a consistently better performance ($P<.05$) for the men on all tests. To further evaluate that difference, relative female performance based on the mean values for men and women for each test and load was calculated. The smaller mean score was used in the numerator of the ratio and, consequently, all values were less than one. This meant that the mean score for women always appeared in the denominator and that for the men in the numerator, except for the long jump test. These ratios for all tests and load conditions are presented in Table 14.

Table 14

Relative Performance: Female vs. Male on Performance Tests Under Five Load Conditions

	Load					
	1	2	3	4	5	Total
10-Yard Run	.85	.83	.82	.78	.81	.81
25-Yard Run	.88	.86	.85	.80	.82	.84
Long Jump	.79	.77	.73	.72	.72	.74
Reaction Movement Right	.89	.88	.86	.86	.86	.87
Reaction Movement Left	.89	.87	.86	.86	.86	.87
Ladder Climb	.67	.67	.61	.43	.41	.52
Agility Run	.88	.86	.85	.80	.82	.84

A consistent decrease in relative performance can be seen for all tests which reflects the significant interactions. This is less noticeable for the reaction movement tests, while the ladder climb showed the greatest effect. In terms of the overall mean performance, five tests showed relative performance between .81 and .87. The poorest relative performance was observed for the long jump (.74) and ladder climb (.52).

Relationships between Performance and Height, Weight, and Percent Body Fat

Correlations between the anthropometric measures of height, weight, and percent body fat and performance test scores were calculated for men and women separately as a means of evaluating the influence of body size. For all tests but long jump, a positive correlation coefficient indicates a negative relationship since the performance criterion is time with a lower value indicating a better time. The results are presented in table form beginning with Table 15, which contains the correlations for 10- and 25-yard runs.

Table 15

Relationships Between Height, Weight, Percent Body Fat and 10- and 25-Yard Run Times for Men and Women

Performance Test	Loads 1	2	3	4	5	6
10-Yard Run Time (sec)						
Men (N=16)						
Height	0.35	0.23	0.25	0.09	0.12	-0.03
Body Weight	0.44	0.18	0.27	0.05	0.05	0.14
Percent Body Fat	0.48*	0.28	0.44	0.29	0.38	0.43
Women (N=14)						
Height	0.08	0.36	0.14	0.13	-0.06	
Body Weight	0.44	0.44	0.25	0.23	0.10	
Percent Body Fat	0.10	0.03	0.06	0.11	0.05	
25-Yard Run Time (sec)						
Men (N=16)						
Height	0.13	0.05	0.07	0.01	0.01	-0.05
Body Weight	0.29	0.28	0.32	0.14	-0.03	0.10
Percent Body Fat	0.27	0.62*	0.55*	0.40	0.31	0.41
Women (N=14)						
Height	0.26	0.29	0.20	0.10	0.01	
Body Weight	0.58*	0.25	0.31	0.24	0.26	
Percent Body Fat	0.17	-0.03	0.10	0.12	0.18	

*P<.05

It is evident that height is not related to performances for either males or females. Body weight for men was not important while, for women, a consistent positive tendency was present indicating poorer performance was associated with greater body weight. The correlation for percent body fat revealed no relationship for females, but a positive one for males. This suggests that subjects with higher proportions of body fat were less proficient in these tests. The results for the Long Jump are presented in Table 16.

Table 16

Relationships between Height, Weight, Percent Body Fat and Long Jump Distance for Men and Women

Sex	Variable	Loads 1	2	3	4	5	6
Men (N=16)							
	Height	0.22	0.41	0.31	0.35	0.57*	0.63*
	Body Weight	0.15	0.30	0.13	0.18	0.41	0.52*
	Percent Body Fat	-0.20	-0.17	-0.16	-0.29	-0.06	0.04
Women (N=14)							
	Height	0.50*	0.59*	0.52*	0.51*	0.61*	
	Body Weight	-0.06	-0.04	-0.08	-0.11	0.13	
	Percent Body Fat	-0.28	-0.22	-0.28	-0.33	-0.17	

* (P<.05)

The height factor is clearly important in this test as all correlations are significant for the women and two of six for the men. In this case, a positive correlation reflects a positive relationship because a higher score indicates a better performance. This result is explained by the fact that the test favors taller people, unlike a vertical jump in which the effect of height can be cancelled out. It was interesting to note that body weight (which is generally related to height) was not associated with long jump performance, with the exception of Load 6 Condition for men. Most of the correlations for body fat were negative, but low and non-significant. The negative direction would be expected, but the size of the coefficient indicates this factor to be of little importance to long jump performance.

Reaction movement correlations for both right and left directions are presented in Table 17. The height correlations for men and women on both tests are all near zero. Body weight appeared to be negatively related to performance, but only for Load 1 Condition. The percent body fat relationships were generally low with one or two exceptions for the men. Overall, none of the three factors were of much importance to performance.

Table 17

Relationships between Height, Weight, Percent Body Fat and Reaction Movement Time Right and Left for Men and Women

Performance Test	Loads 1	2	3	4	5	6
Reaction Movement Right (sec)						
Men (N=16)						
Height	0.11	-0.03	-0.02	-0.05	-0.32	0.11
Body Weight	0.41	0.34	0.27	0.12	-0.15	-0.17
Percent Body Fat	0.36	0.51*	0.45	0.16	0.34	0.09
Women (N=14)						
Height	-0.10	-0.12	-0.05	0.07	-0.29	
Body Weight	0.47*	0.14	-0.25	0.33	0.01	
Percent Body Fat	0.35	0.02	0.14	0.15	-0.02	
Reaction Movement Left (sec)						
Men (N=16)						
Height	0.04	-0.21	-0.20	-0.18	-0.13	-0.27
Body Weight	0.31	0.04	0.14	0.01	0.14	0.41
Percent Body Fat	0.36	0.34	0.34	0.24	0.42	0.01
Women (N=14)						
Height	0.17	-0.03	0.07	-0.07	-0.06	
Body Weight	0.60*	0.41	0.38	0.15	0.23	
Percent Body Fat	0.31	0.33	0.16	0.06	0.20	

*$P<.05$

The results for the Ladder Climb are shown in Table 18. It is obvious that performance on this test is not related to the factors of height, weight and percent body fat. Only one of the 33 coefficients is significant, that being body weight for females under Load Condition 1.

Table 18

Relationships Between Height, Weight, Percent Body Fat and Ladder Climb Time for Men and Women

Sex	Variable	Loads 1	2	3	4	5	6
Men (N=16)							
	Height	0.01	0.09	0.12	-0.30	-0.27	-0.29
	Body Weight	-0.01	-0.03	0.21	-0.13	-0.18	-0.29
	Percent Body Fat	0.09	0.16	0.39	0.32	0.23	0.24
Women (N=14)							
	Height	0.20	0.10	0.25	0.11	0.01	
	Body Weight	0.50*	0.26	0.45	0.08	0.01	
	Percent Body Fat	0.31	0.19	0.19	0.13	0.00	

*P<.05

Agility Run Time results appear in Table 19. The height data indicate no association with performance. Body weight was negatively related (positive correlation) for the first three loads (3 of 6 coefficients were significant). The men reflected a consistent, negative relationship for body fat indicating higher proportions of fat were detrimental to performance. This was not true for the women, however, as their correlations were all low and non-significant.

Table 19

Relationships Between Height, Weight, Percent Body Fat and Agility Run Time for Men and Women

Sex	Variable	Loads 1	2	3	4	5	6
Men (N=16)							
	Height	0.28	0.22	0.09	-0.10	-0.13	0.02
	Body Weight	0.40	0.58*	0.48*	0.32	0.15	0.22
	Percent Body Fat	0.31	0.63*	0.53*	0.51*	0.42	0.35
Women (N=14)							
	Height	0.08	0.12	0.15	0.04	-0.28	
	Body Weight	0.59*	0.42	0.32	0.19	0.03	
	Percent Body Fat	0.36	0.16	0.09	0.07	0.04	

*P<.05

Summary. Although certain trends were present for some tests, these were not consistent over the full range of tests. The least important factor appeared to be height which was only related to long jump performance. Body weight was the most important factor related to test performance. This variable tended to be a negative factor which hampered performance. The results for percent body fat revealed virtually no association with performance for women and only a modest negative relationship on some tests for men.

The analysis included a total of 231 correlation coefficients, of which 22 were significantly different from zero. Based on the .05 level of probability, approximately 12 coefficients would be significant due to chance alone. Also, the highest coefficient obtained was 0.63, which is of relatively little value for predictive purposes. Consequently, it must be concluded that the variables of height, weight, and percent body fat taken separately are not major factors in determining success on the performance tests used in this project. This may be due in part to the interactive nature of these factors relative to the biomechanical requirements of the performance tests. In any case, it appears that these factors, taken independently, and when evaluated within sexes, are not dominant factors in the execution of these maximal effort performance tests.

Analysis of Load Conditions

The ANOVA results indicated that a significant main effect for load was present for all performance tests. In most cases, the internal analyses revealed significant differences among Loads 1 through 4, but not between Loads 4 and 5. An evaluation of these loads relative to the body weight of the subjects and to their performance under Condition 1 (control) was also conducted.

Absolute Mean Loads. The loads above normal and lean body weight (B.W.) are presented in Table 20, and Figures 20 and 21.

Table 20

Absolute Mean Loads (kg) for
Men and Women for Each Load Condition

Base Condition	$\bar{X}$	N	Load Condition 1	2	3	4	5	6
Body Weight (kg)								
Men	69.84	16	.77	9.41	17.59	29.93	36.73	43.53
Women	59.91	14	.59	9.07	16.95	29.29	36.09	---
Lean Body Weight (kg)								
Men	58.11	16	12.50	21.14	29.32	41.66	48.46	55.26
Women	45.89	14	14.60	23.08	30.95	43.30	50.10	---

By using body weight as a reference, the values reflect the mean loads added to the body for the six load conditions. Mean load values were also determined on the basis of lean body weight. The values obtained represent the external load applied to the body plus the mean weight attributed to body fat. They were included as a way of incorporating the concept of percent body fat into the analysis and discussion of the results. These data are presented graphically in Figures 20 and 21.

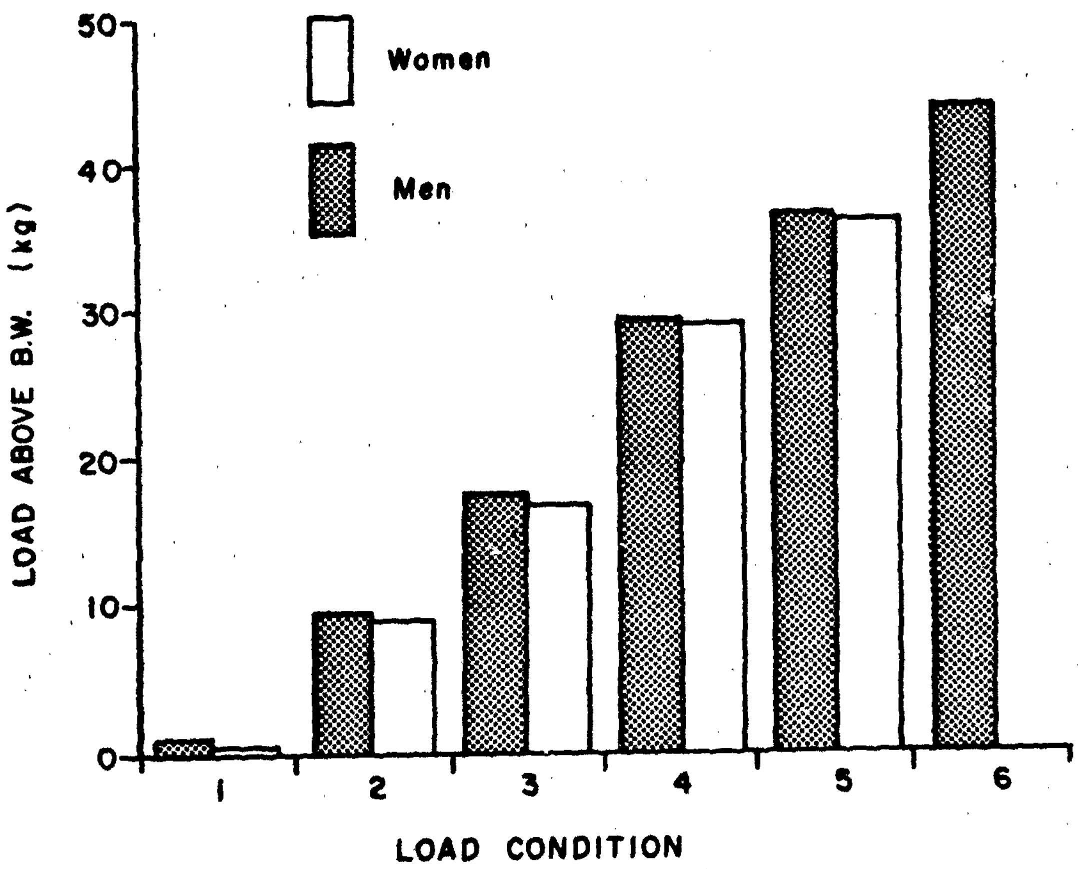

Figure 20. Added Load above Body Weight for each Load Condition.

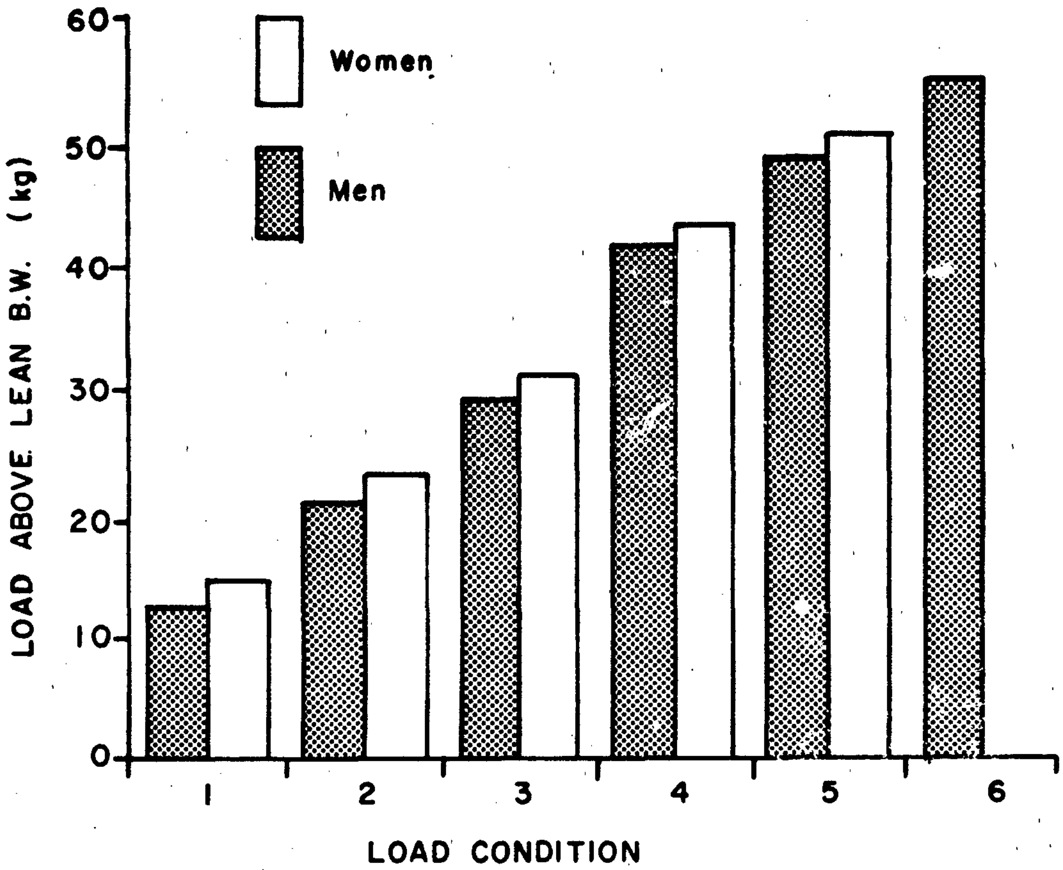

Figure 21. Added Load Above Lean Body Weight for Each Load Condition.

The diagrams show a systematic increase in load across the experimental load conditions. It should be emphasized, however, that the distribution of these added loads on the body is not uniform. For example, the added weight appears at the waist for the fighting gear, on the feet for the boots, extended posteriorly in the pack, etc.

Relative loads. It is also important to evaluate these loads in light of the differences in body weight and lean body weight of the subjects. The relative mean loads presented in Table 21 and Figures 22 and 23 were derived from the ratio of the load and means for both total body weight and lean body weight.

Table 21

Relative Mean Loads for Men and Women for Each Load Condition

Variable	Sex	N	Load Condition 1	2	3	4	5	6
Load/B.W.								
	Men	16	.01	.13	.25	.43	.53	.62
	Women	14	.01	.15	.28	.49	.60	--
Load/L.B.W.								
	Men	16	.22	.36	.50	.72	.83	.95
	Women	14	.32	.50	.67	.94	1.09	--

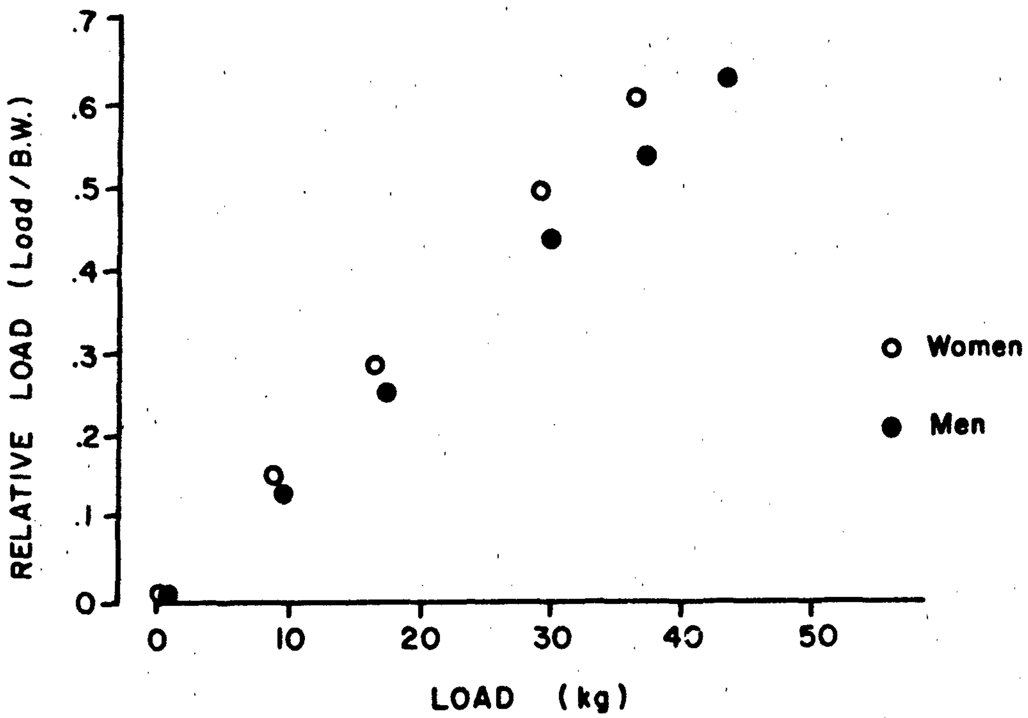

Figure 22. Load Relative to Body Weight for each Load Condition.

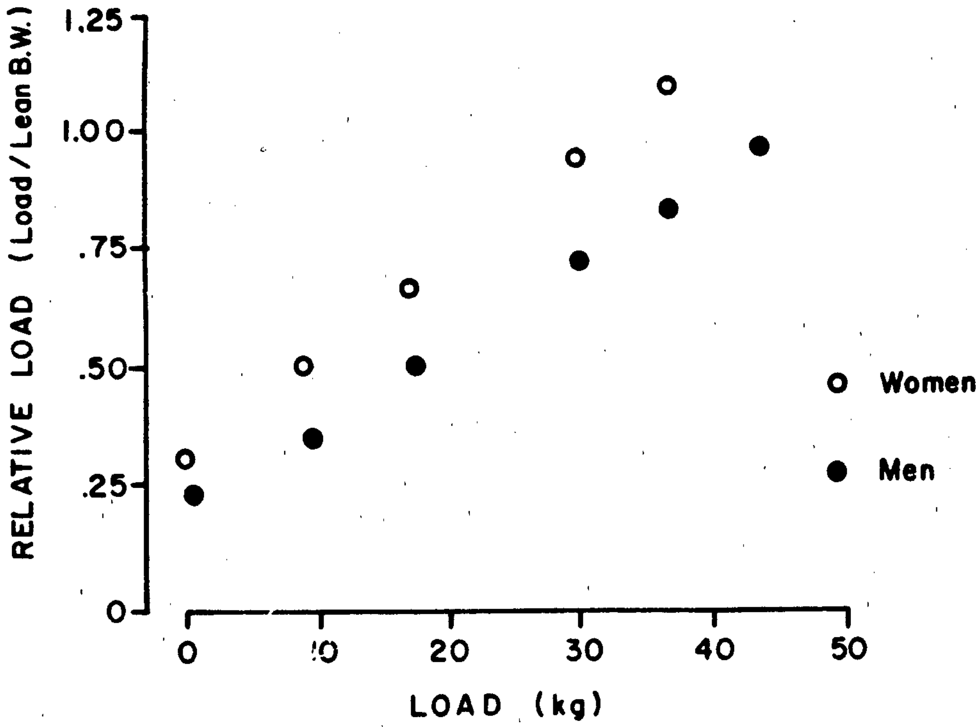

Figure 23. Load Relative to Lean Body Weight for each Load Condition.

The mean values for the female subjects tend to be higher due to their lower body weight and higher percent body fat. This is increasingly apparent as the load values increase. These results indicate that the females must necessarily carry greater relative loads than their male counterparts, which explains in part their lower test performance levels.

The relative loads may also be expressed as a proportion of the load under Condition 1 (Control). This was done by dividing Body Weight by Body Weight plus added Load and Lean Body Weight by Lean Body Weight plus added Load. These values for the male and female subjects appear in Table 22.

Table 22

Relative Load Based on Normal and Lean Body Weight for Men and Women

		Loads					
		1	2	3	4	5	6
Body Weight							
Men	69.84 kg	1.00	.87	.80	.70	.66	.62
Women	59.91 kg	1.00	.87	.78	.67	.63	--
Lean Body Weight							
Men	58.11 kg	.82	.73	.66	.58	.54	.51
Women	45.89 kg	.75	.66	.59	.51	.48	--

Relative effects of load on performance. The results reflect the decrement in proportionate load values which can be used for general comparative purposes with performance decrement data. Table 23 contains such information based on the mean performance for Condition 1. The proportionate values represent the decrease in performances for both subject groups.

Table 23

Relative Effects of Load on Male and Female Performance

Test	Sex	Load Conditions 1	2	3	4	5
10-Yard Run	M	1.00	.92	.88	.83	.84
	F	1.00	.90	.85	.76	.76
25-Yard Run	M	1.00	.93	.89	.82	.81
	F	1.00	.91	.85	.74	.75
Long Jump	M	1.00	.91	.87	.77	.74
	F	1.00	.88	.81	.70	.67
Reaction Movement R	M	1.00	.97	.94	.88	.87
	F	1.00	.96	.92	.85	.85
Reaction Movement L	M	1.00	.97	.94	.88	.87
	F	1.00	.94	.91	.84	.84
Ladder Climb	M	1.00	1.04	1.03	.80	.72
	F	1.00	1.03	.94	.52	.44
Agility Run	M	1.00	.93	.89	.82	.81
	F	1.00	.91	.85	.74	.75
$\overline{X}$		1.00	.94	.90	.78	.77

As expected, the decrease in ratios across loads was greater for female than male subjects. In general, the rate of decrease was less for these performance tests than that of the proportional load decrements. The exception was for ladder climb performance of the female subjects. Overall the performance of the subjects was not as adversely affected as might be expected, based on the magnitude of the additional load they carried.

Discussion

The results of these performance tests constitute valuable information concerning the effects of selected loads on combative movements. The load conditions (five for women and six for men) covered a wide range of the loads carried by the typical foot soldier. The mean loads for the men ranged from .77 kg to 43.53 kg, the latter representing 65% of body weight. The female mean loads began at .59 kg and ended at 36.09 kg, 60% of the mean body weight. The inclusion of Load 1 in which subjects wore shorts, t-shirt and sneakers had not been done in previous load carrying studies and was especially useful for comparative purposes. It is important to emphasize that not only are the absolute loads important but the locations of the components of the load relative to the body are also critical. For example, the addition of the helmet to the head has a different effect upon performance than a similar weight attached to the fighting gear belt. The boot weight located at the extremity is not comparable to the same load in the form of an M-16 rifle held in the hands. Furthermore, the equipment itself may influence the performance. For example, changing from sneakers to boots may have significantly influenced running and other movements, while the shoulder straps on the packs could have affected arm movement during the ladder climb. Holding the rifle required a different movement pattern than when the arms were free to move normally. In any case the loads were positioned in the manner typically found in the military and, consequently, the results are considered of practical value.

The test results showed a clear difference favoring the male over the female subjects. In five of the tests, however, the maximum mean difference was 19% or less. Only in the long jump (74%) and ladder climb (52%) could the mean differences be described as major. It is important to note that these two tests required maximal effort to move the center of gravity vertically against gravity which accentuates the physical limitations of the female subjects. Their performance was considerably better in the events in which they moved in a horizontal direction; this required less direct work against gravity. It must be remembered, however, that the subjects were in a non-fatigued state during the performance of these tests. Consequently, the differences noted between men and women might well be much greater if they had been subjected to great physical exertion in the testing process. Some indication of this effect could be seen in the performance under Load 4, which in many cases was poorer than Load 5. This unexpected result was due to the experimental design which included testing of Loads 3 and 4 on the same day, while Load 5 was included alone in a single test session.

The relationship between body size (height and weight) and percent body fat and performance was examined using correlational methods. With the exception of a few isolated cases, these factors, considered independently, were not related to performance. This was especially evident for the 10- and 25-yard sprints were only body fat for men was negatively related to performance, and reaction movement right and left where only 3 of 66 correlations were significant. Body weight in the agility run was a negative factor while height in the long jump was a positive factor. It appears that, within the ranges of body size of the male and female subjects tested, neither height, weight, nor percent body fat considered independently are associated consistently with combative movement performance as measured in this experiment.

The results obtained in this study provide useful information concerning the effects of added load on maximal effort performance tests. For most tests the systematic increase in load produced a systematic decrease in performance. The men performed better than the women on all tests and these differences tended to be greater for the higher load conditions. Body size was not consistently associated with performance across the tests when male and female subjects were treated separately. This suggests that other factors such as the specific biomechanical requirements of each test may be interacting with the body size components, thereby reducing their influence upon performance.

References

1. Allen, T.H., M.T. Peng, K.P. Chen, T.F. Huang, and H.S. Fang. Prediction of total adiposity from skinfolds and the curvilinear relationship between external and internal adiposity. Metabolism 5:346-352, 1956.

2. Dubois, D. and E.F. Dubois. Clinical calorimetry: A formula to estimate the appropriate surface area if height and weight be known. Arch. Intern. Med. 17:863, 1916.

3. Skerlj, B., J. Brozek, and E.E. Hunt, Jr. Subcutaneous fat and age changes in body build and body form in women. Am. J. Phys. Anthrop. 11:577-600, 1953.

4. Behnke, A.R. and J.H. Wilmore. Evaluation and Regulation of Body Build and Composition. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1974.

5. White, R.M., and E. Churchill. The Body Size of Soldiers: US Army Anthropometry - 1966 (Tech. Rep. 72-51-CE). Natick, Mass: US Army Natick Laboratories, pp. 71 and 73, December 1971.

6. Churchill, E., T. Churchill, J.T. McConville, and R.M. White. Anthropometry of Women in the US Army - 1977: Report No. 2 - The Basic Univariate Statistics (Tech. Rep. NATICK/TR-77/024). Natick, Mass: US Army Natick Research and Development Command, p. 46, June 1977.

Appendix A

Clothing and Equipment Used in This Study

PRECEDING PAGE BLANK-NOT FILMED

Clothing, Body Armor, and Sleeping Gear

The items worn by the subjects or stowed in the packs are standard products from the Army's inventory. The Army nomenclature for each item and its military specification, which contains a complete description of the item, are listed below.

Nomenclature	Specification
Socks, Wool, Cushion Sole	MIL-S-48
Boot, Combat, Leather, Black, Direct Molded Sole	MIL-B-43481E
Shirt, Utility, Durable Press	MIL-S-43929B
Trousers, Utility, Durable Press	MIL-T-43932C
Undershirt, Cotton, White	JJ-U-513D
Helmet, Personnel Armor System Ground Troops (PASGT)	LP/P DES 12-78A
Body Armor, Fragmentation Protective Vest, Personnel Armor System Ground Troops (PASGT)	MIL-B-44053
Sleeping Bag, Intermediate Cold, Synthetic Fill	MIL-S-44016
Mattress, Pneumatic, Insulated	MIL-M-43968
Bag, Waterproof, Clothing	MIL-B-3108
Poncho, Wet Weather	MIL-P-43700

Load Carrying Equipment

In the Army, all items worn or carried by the soldier are divided into two categories, a fighting load and an existence load. The former consists of items essential for the immediate mission, such as the clothing and armor being worn, a rifle, ammunition, and a canteen. The existence load consists of items needed to sustain the soldier in the field for a period of time, such as sleeping gear, rations, and additional clothing. Carrying equipment has been developed to accommodate some of the items comprising the fighting and the existence loads. The load carrying equipment which was used in the present study is described below.

Fighting Gear (Figure A-1). This standard Army equipment consists of a belt and suspenders, made of nylon webbing and nylon duck, to which other items are attached by means of slide keepers. The equipment hung on the belt includes:

a. a cover made of nylon duck that holds a steel cup with a .9-liter capacity and a .9-liter canteen for water.

b. a plastic case that holds a folding intrenching tool.

c. two cases made of nylon duck which hold ammunition rounds and also have straps from which grenades can be hung.

d. a small pouch for first aid dressings or a compass.

The Army nomenclature and military specification for each component of the fighting gear are listed below.

Nomenclature	Specification
Belt and Suspenders, All-Purpose Lightweight Individual Carrying Equipment (ALICE)	MIL-B-43826 and MIL-S-43819
Canteen, Water, 1-Quart Capacity	MIL-C-43103

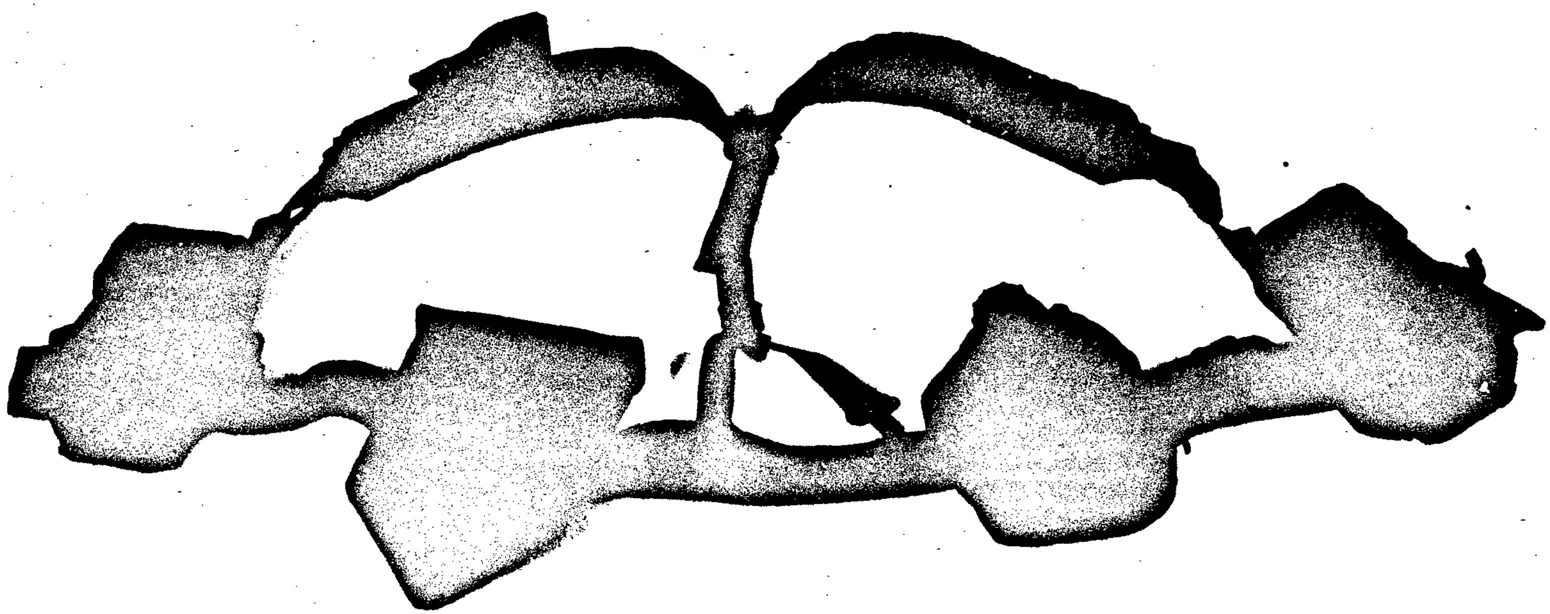

Figure A-1. ALICE Fighting Gear.

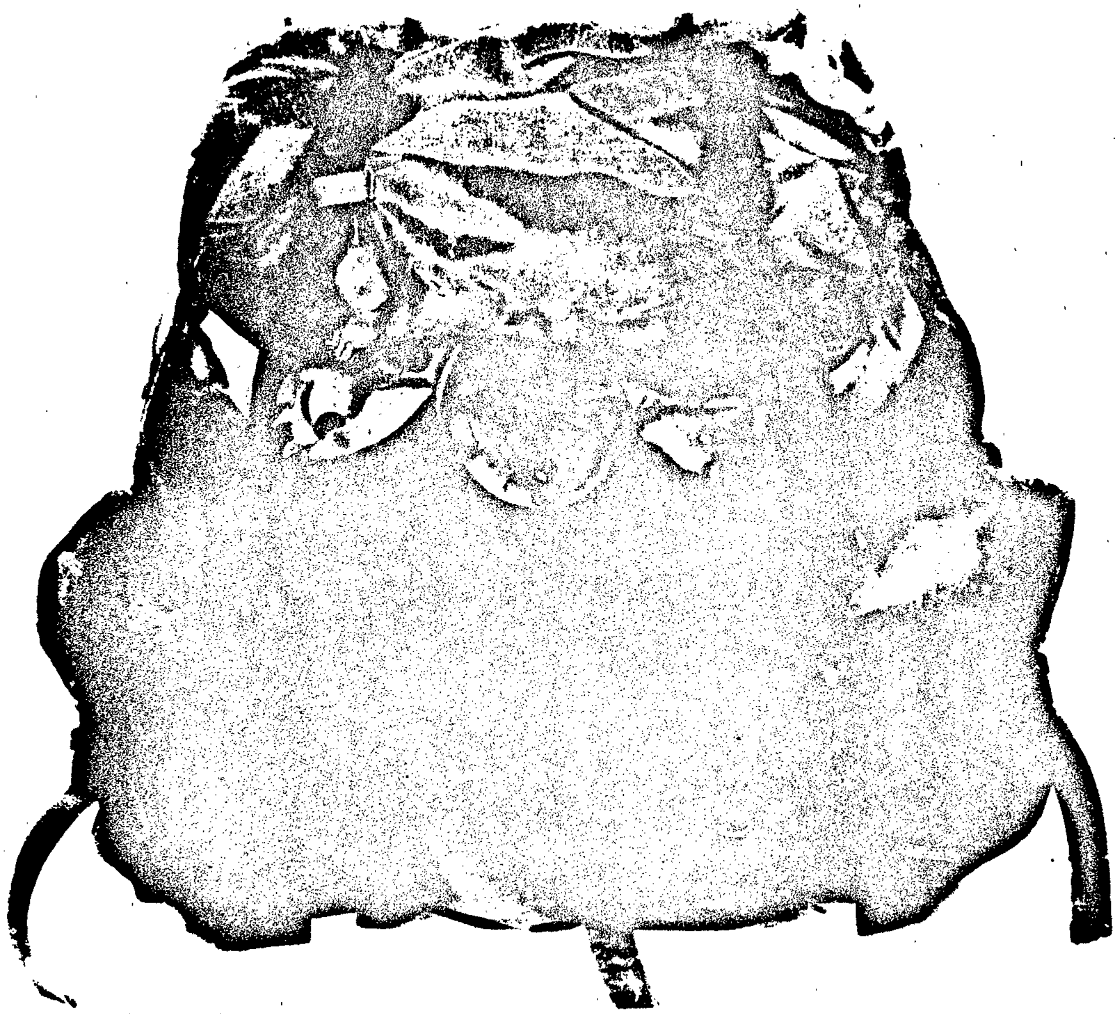

Figure A-2. ALICE Pack.

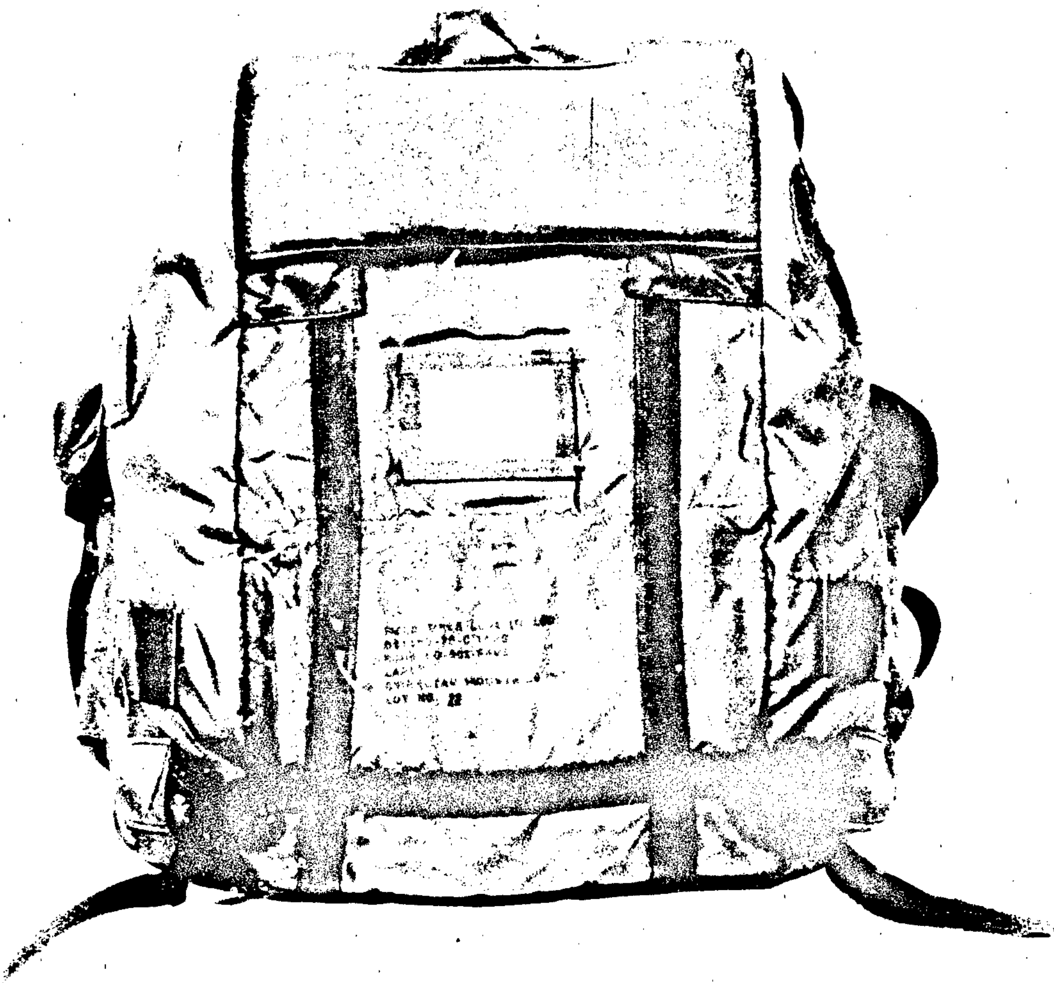

Figure A-2. ALICE Pack.

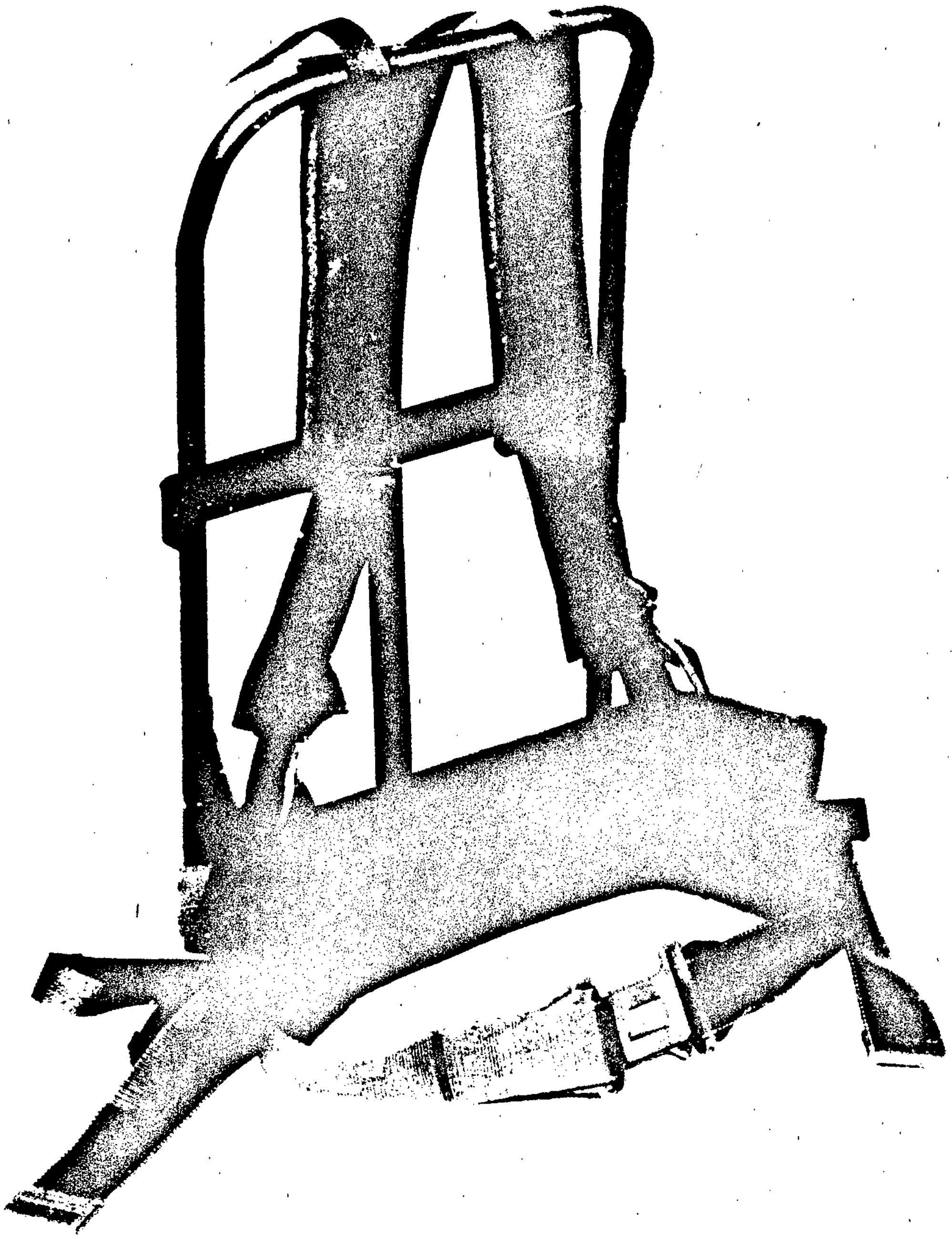

Figure A-3. ALICE LC-2 Frame.

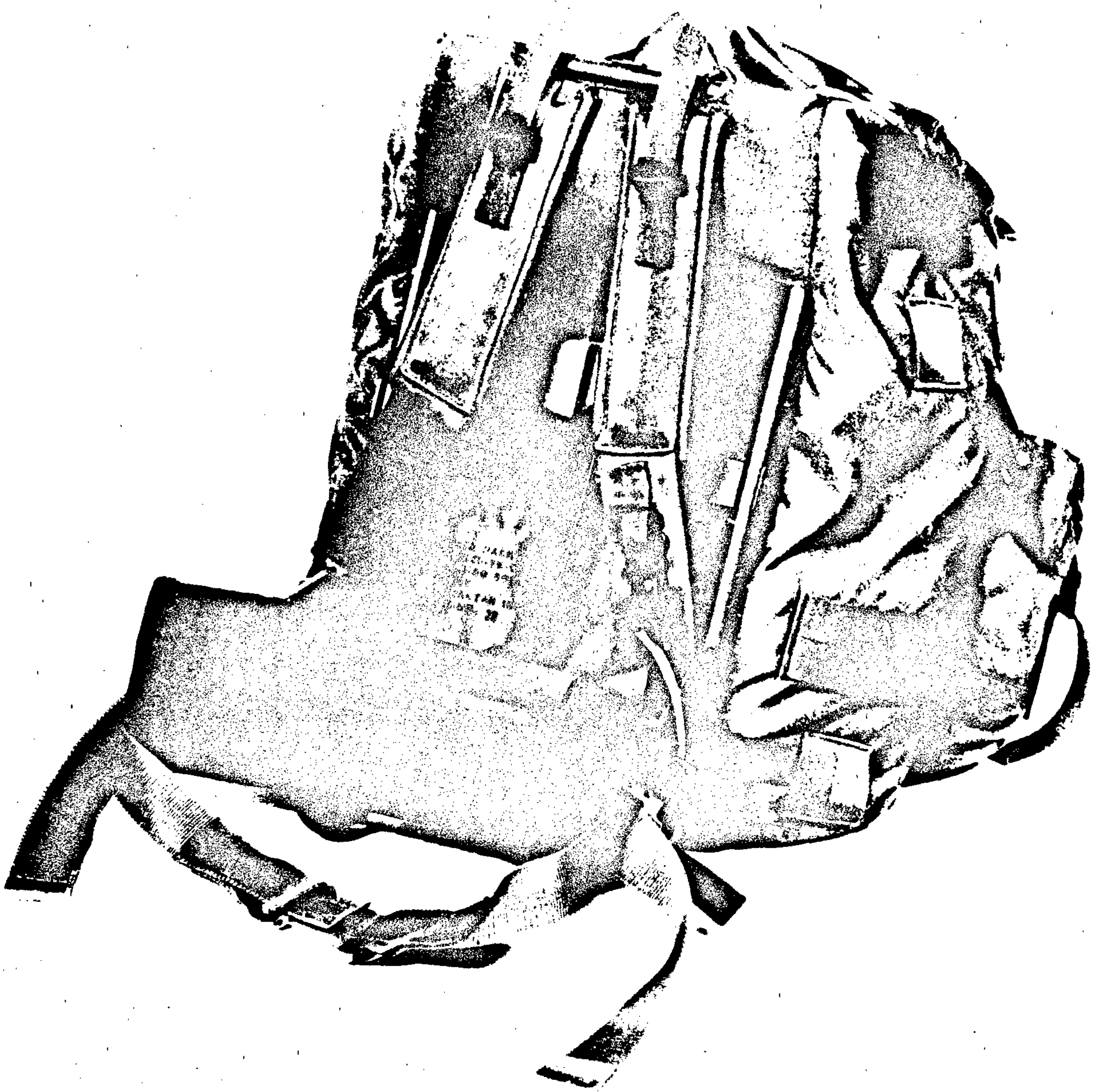

Figure A-3. ALICE LC-2 Frame.

Nomenclature	Specification
Cup, Water Canteen, Steel, 1-Quart	MIL-C-43761
Cover, Canteen	MIL-C-43742
Intrenching Tool, Folding, Lightweight	MIL-I-43684
Intrenching Tool Carrier	MIL-I-43831
Case, Small Arms, Ammo, 30-Round	MIL-C-43827
Case, First Aid/Compass	MIL-C-43745

Carrying Gear for Existence Load. This standard, Army equipment consists of a backpack with an external frame. These items, together with the fighting gear, comprise a load carrying system designated as All-Purpose Lightweight Individual Carrying Equipment (ALICE).

The ALICE pack (Figure A-2) is made of nylon duck and nylon webbing and weighs 1.3 kg. It has a large, top-loading, main compartment, an outside pocket on each of two sides and the front, and three smaller pockets above the center outside pocket. The maximum capacity of the pack is approximately 32 kg. The main compartment can be closed by means of a drawstring and is covered by a storm flap. The flap is secured by two, vertical straps which encircle the pack. Each outside pocket has a drawstring closure and is covered by a flap which is secured by a single strap. Strips of webbing sewn on the outside surface of the main compartment can be used for attaching items. A pocket large enough to accommodate a field radio is sewn inside the main compartment on the surface closest to the wearer's back. There are also "D" rings and tie strings inside the main compartment which can be used to shorten the pack if it is not filled to capacity. The pack is attached to the frame by means of an envelope at the top of the pack which slides over the top of the frame and a strap with a buckle on the bottom of each side of the pack which wraps around the frame.

The ALICE frame (Figure A-3) with its associated straps carries the designation "LC-2" to differentiate it from a frame of similar design (LC-1) which it replaced in the Army's inventory. The ALICE LC-2 frame is structured of aluminum tubing. It is 50.8 cm high and 31.1 cm wide. There are two, aluminum, horizontal members made from flat stock which extend from one side of the frame to the other and are riveted to the aluminum tubing. One, aluminum, vertical member, also made from flat stock, is riveted to the top and the bottom of the frame. Toward the top of the frame, this vertical piece and the aluminum tubing are angled toward the wearer's back. Two metal loops are attached to the top, horizontal, tubular portion of the frame. These are used to retain one end of the shoulder straps. There is also a grommet at the lower portion of each side of the frame through which the other end of each shoulder strap passes and is secured.

At the top of each shoulder strap is a rectangular piece of foam spacer material, 22.9 cm long, 7.0 cm wide, and 1.3 cm thick, covered with nylon duck and nylon webbing. The remainder of the strap is unpadded, nylon webbing. A quick-release device and a buckle used for length adjustment are incorporated into each shoulder strap. The lower back strap, which is 43.8 cm long and 12.7 cm high, is also made of foam spacer material, 1.3 cm thick, covered with nylon duck. The back strap is secured to the frame by use of narrow webbing which passes through a buckle. The waist belt is comprised of two pieces of nylon webbing 4.4 cm wide. One end of each piece is sewn to the backstrap. Each piece includes an adjustment mechanism used to shorten or lengthen the belt. The belt is secured around the waist by a plastic, quick-release device. The frame with its associated straps weighs 1.7 kg.

The Army nomenclature and military specifications for the components of this load carrying equipment are listed below.

Nomenclature	Sepcification
Field Pack, Nylon, Large, All-Purpose Lightweight Individual Carrying Equipment (ALICE)	MIL-F-43832
Straps, Pack Frame and Strap/Frame Assembly, LC-2, All-Purpose Lightweight Individual Carrying Equipment (ALICE)	MIL-S-43835

Appendix B

ANOVA Summary Tables

PRECEDING PAGE BLANK-NOT FILMED

Table B-1

ANOVA Summary for
10-Yard Time

SOURCE OF VARIANCE	df	M.S.	F.
<u>Between Subjects</u>			
Gender	1	7.50	107.1*
Error	28	.74	
<u>Within Subjects</u>			
Load	4	1.48	267.7*
Gender x Load	4	.96	17.4*
Error	112	.55	

*P<.01

Table B-2

ANOVA Summary for
25-Yard Time

SOURCE OF VARIANCE	df	M.S.	F.
<u>Between Subjects</u>			
Gender	1	78.57	73.8*
Error	28	1.07	
<u>Within Subjects</u>			
Load	4	23.64	389.7*
Gender x Load	4	1.65	27.2*
Error	112	.61	

*P<.01

Table B-3

ANOVA Summary for
Long Jump Distance

SOURCE OF VARIANCE	df	M.S.	F.
Between Subjects			
Gender	1	10.41	121.3*
Error	28	.08	
Within Subjects			
Load	4	2.11	472.3*
Gender x Load	4	.007	1.5
Error	112	.004	

*P<.01

Table B-4

ANOVA Summary for
Right Reaction Movement Time

SOURCE OF VARIANCE	df	M.S.	F.
Between Subjects			
Gender	1	2.86	89.7*
Error	28	.032	
Within Subjects			
Load	4	.50	126.4*
Gender x Load	4	.013	3.23*
Error	112	.004	

*P<.01

Table B-5

ANOVA Summary for
Left Reaction Movement Time

SOURCE OF VARIANCE	df	M.S.	F.
Between Subjects			
Gender	1	2.84	95.0*
Error	28	.030	
Within Subjects			
Load	4	.51	175.8*
Gender x Load	4	.019	6.5*
Error	112	.003	

*P<.01

Table B-6

ANOVA Summary for
Ladder Climb Time

SOURCE OF VARIANCE	df	M.S.	F.
Between Subjects			
Gender	1	216.40	60.4*
Error	28	3.58	
Within Subjects			
Load	4	44.3	61.4*
Gender x Load	4	20.4	28.3*
Error	112	.72	

*P<.01

Table B-7

ANOVA Summary for
Agility Run Time

SOURCE OF VARIANCE	df	M.S.	F.
Between Subjects			
Gender	1	78.6	73.8*
Error	28	1.1	
Within Subjects			
Load	4	23.6	389.7*
Gender x Load	4	1.6	27.1*
Error	112	.06	

*P<.01