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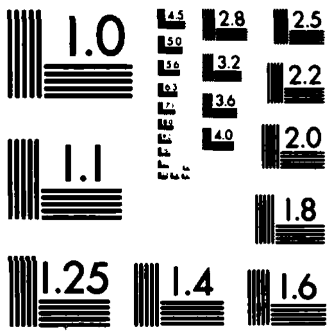

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TECHNICAL REPORT AHS - 6

JULY 1983

LIFTING AND TASK PERFORMANCE CAPACITY FOR ARMY MEDICAL DEPARTMENT ADVANCED INDIVIDUAL TRAINING MEDICS

TO CONSERVE FIGHTING STRENGTH

INDIVIDUAL TRAINING DIVISION
DIRECTORATE OF TRAINING DEVELOPMENT
ACADEMY OF HEALTH SCIENCES, U.S. ARMY
FT. SAM HOUSTON, TX 78234

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The purpose of this study was to determine the extent of physical lifting capacity (PLC) for male and female Army 91B10 medics and to assess the load requirements for three field medical tasks. A sample of 786 soldiers (494 men, 292 women) from three training companies were measured on a box lifting test at loads of 70, 80, and 90 lb. Virtually all medics within the PLC limits of 80-90 lb. (8 males, 71 females) successfully accomplished the casualty survey and evacuation tasks. Results indicated that the three 91B10 medical tasks should be reclassified as moderately heavy vs. heavy under the physical demands occupational coding system.

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Technical Report AHS - 6

July 1983

Lifting and Task Performance Capacity For Army Medical Department Advanced Individual Training Medics

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Summary

PURPOSE:

To determine the physical lifting capacity of 91B10 AIT soldiers and their ability to perform 3 tasks which were rated as heavy by strict interpretation of the Physical Demands Analysis Worksheet.

METHODOLOGY:

1. A total of 786 91B10 AIT soldiers (494 males, 292 females) in their ninth week of AIT training were screened utilizing a physical demands lift capacity test. The test included a baseline trial that required all soldiers to lift an 80 pound box from ground level to the bed of a 2½ ton truck. Those who successfully completed this task then attempted to lift a 90 pound box to the same height. Soldiers who did not lift 80 pounds attempted to lift 70 pounds to the same height.

2. Those soldiers who lifted 80 pounds but were unable to lift 90 pounds (n = 79: 8 male, 71 female) were subject to 3 criterion performance tasks in a field environment. The tasks were:

   a. One man evacuation, distance 20 meters, utilizing drag method.

   b. Survey the casualty, prone position.

   c. Two man evacuation, distance 50 meters, utilizing cross arm carry.

FINDINGS:

For the subset of 79 soldiers tested on the three field performance tasks, all (100%) accomplished tasks "a" and "b" to standards, while 77 of 79 soldiers successfully completed task "c". Thus of 237 heavy task trials (79 students X 3 tasks) 235 (99.16%) were performed to standards by soldiers who did not meet the corresponding lift capacity required by the Physical Demands Analysis Worksheet.

CONCLUSIONS:

1. The performance test results justify ranking the three tasks as moderately heavy.

2. The application of the Physical Demands Analysis Worksheet data must be judiciously applied in conjunction with performance.

RECOMMENDATION:

1. The proposed MOS 91A10 be classified moderately heavy.

2. All physical demands analysis data be validated by performance criteria prior to implementation.

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Lifting and Task Performance Capacity For AMEDD AIT Medics

While it is a long recognized and established fact that men are generally stronger than women, and can be expected to lift heavier loads, the premier question addressed by this study centers on the assessment of gender differences in relation to actual medical task performance. This study consisted of three phases. The objective of the first phase was to establish by a series of weighted box lifts the load parameters and differences between male and female AMEDD enlisted AIT personnel. The second phase of this study was to determine by a series of field-type performance tasks the corresponding parameters and differences between male and female task accomplishment. Finally the third phase examined the relationship between the established baseline lifting capacity data and the actual task performance capabilities of male and female enlisted medics.

Medic Lifting Capacity at Various Load Levels Phase I

In the first phase of the study 786 AIT medics (494 males and 292 females) attempted to lift an 80-pound box onto the bed of a 2½ ton truck. Subjects from three companies (Co.'s B, C, and D) participated in the study. The 80-pound box lifting task was initially employed to serve as a baseline in establishing lifting capacity for males and females (Box A). In addition, two other weighted boxes -- Box B (90-pounds) and Box C (70-pounds) were employed for subsamples of the 786 to determine lower and upper bounds for lifting capacity from the initial 80-pound baseline measure. Table 1 presents the procedural design used in the first phase of the study and also presents the frequencies associated with male and female lifting capacity.

Table 1

Procedural Design and Frequencies

For Lifting Capacity - Phase I

Baseline - Box A 80-pounds

	No lift	Lift	Total
Males	1	493	494
Females	55	237	292
Total	56	730	786

to lower limit → Box C 70-pounds

to higher limit → Box B 90-pounds

Box C 70-pounds

	No lift	Lift	Total
Males	0	1	1
Females	8	47	55
Total	8	48	56

Box B 90-pounds

	No lift	Lift	Total
Males	8	485	493
Females	71	166	237
Total	79	651	730

As shown, 56 of the 786 soldiers could not lift the 80-pound weight and were then assigned to the 70-pound condition. Of those 56, 48 were capable of lifting the 70-pound box. Similarly, of the 786 soldiers who were successful in lifting the 80-pound baseline measure, 730 were assigned to the 90-pound condition.

To analyze the frequencies associated with the full sample baseline measure, a set of variables was generated consisting of a criterion measure for lifting and a series of predictor measures which provide information about Company membership, gender, time of day, and specific gender-by-company membership. Definitions of these variables are presented in Table 2.

Table 2

Definitions of Criterion and Predictor Variables For Full Sample - 80-pound Baseline

Variable	Symbol	Operational Definition
Criterion:		
Lift vs. No lift	Y	A set of observations for 786 soldiers coded 1 if the soldier could lift an 80 lb. box onto the bed of a 2½ ton truck, 0 otherwise
Predictors:		
Company		
Co. B	BRAVO	Coded 1 if soldier was in B Co., 0 otherwise
Co. C	CHARLIE	Coded 1 if soldier was in C Co., 0 otherwise
Co. D	DELTA	Coded 1 if soldier was in D Co., 0 otherwise
Gender		
	MALE	Coded 1 if soldier was male, 0 otherwise
	FEMALE	Coded 1 if soldier was female, 0 otherwise
Time of day	TOD	Coded 1 if soldier was observed in morning (AM), 0 if observed in afternoon (PM)
Gender-by-Company	BM	BRAVO times MALE
	BF	BRAVO times FEMALE
	CM	CHARLIE times MALE
	CF	CHARLIE times FEMALE
	DM	DELTA times MALE
	DF	DELTA times FEMALE

While the primary interest of the first phase of the study was to determine the extent of gender differences at various load levels, two additional control variables were generated. Time of day was included to allow an examination of possible fatigue factors since all soldiers were in training and some performed the lifting tasks in the morning while others performed the tasks toward the end of the working day. In addition, replication samples, by

Company were included to ensure that lifting results would be representative and generalizable to the medic population. Descriptive statistics for all measures are arrayed in Table 3. Since all measures were dichotomously coded (either 1 or 0), the arithmetic mean indicates the proportion of membership associated with a particular variable. For example, the BRAVO

Table 3

Means, Standard Deviations, and Zero-order Validities

For The Full Sample - 80 lb Baseline

Variable	Mean	Standard Deviation	Validity Coefficient[a]
Lifting Criterion	.9288	.2572	1.0000
Company			
BRAVO	.3499	.4769	-.0457
CHARLIE	.2901	.4538	.0027
DELTA	.3600	.4800	.0429
Gender			
MALE	.6285	.4832	.3500*
FEMALE	.3715	.4832	-.3500*
Time of Day (AM)	.5891	.4920	-.0705
Specific Membership			
BRAVO MALE	.2532	.4348	.1499*
BRAVO FEMALE	.0967	.2955	-.2943*
CHARLIE MALE	.2099	.4073	.1428*
CHARLIE FEMALE	.0802	.2715	-.2097*
DELTA MALE	.1653	.3715	.1233*
DELTA FEMALE	.1947	.3959	-.0637

N = 786 soldiers [a]Indicates r statistically significant from zero, $p < .01$.

average of .3499 indicates that 34.99% of the 786 soldiers were members of Company B. Overall the sample consisted of approximately 63% males and 37% females, with 59% of the observations occurring in the morning.

In terms of validity, the highest correlation emerged between lifting and the gender measure. On the average, males appeared to lift at the

80 lb. baseline more often than females. As would be expected, the corresponding coefficient for females was mirrored in the opposite direction (r = -.35). A similar pattern emerged for validities associated with the specific gender-by-company measures with the exception of Co. D females.

Overall, time of day did not appear to be related to lifting capability. Even if the value of r = -.07 approaches significance, it is in the opposite direction expected for a fatigue factor; lifting capacity was slightly higher in the afternoon than in the morning.

Because the validities shown in the table are based upon dichotomous or "point-distributions" they constitute what are referred to as phi coefficients. When the marginal frequencies of 2 x 2 tables are disproportionate, as is evident in this data, the maximal size of phi may be drastically limited, Normally zero-order correlations may vary from +1.0 to -1.0. Guilford and Fruchter (Fundamental Statistics in Psychology and Education, McGraw-Hill, 1973) outline a procedure for determining the maximal value for phi. For gender, phi_{max} = .36. Therefore the validities for gender should be contrasted to a maximal value of .36 rather than +1.0. As shown in the table, the bivariate relationship between lifting and gender is very close to the .36 limit.

To assess the combined effects of all predictor variables upon lifting ability, a series of multiple linear regression equations were calculated and are presented in Table 4. Model A expresses lifting ability as a function of specific gender-by-company membership and time-of-day. As shown, the multiple correlation of R = .41 is greater than the upper phi_{max} limit established between lifting and gender alone and represents a higher level of predictive efficie~~y.

Table 4

Lifting Ability Expressed As A Function of Various Predictor Variables

Model	Multiple Linear Regression Equation	NLIPV[a]	R	R^2
A	$Y = a_0U + b_1BM + b_2BF + b_3CM + b_4CF + b_5DM$ $+ b_6DF + b_7TOD$	7	.41368	.17113
B	$Y = a_0U + b_1BM + b_2BF + b_3CM + b_4CF + b_5DM + b_6DF$	6	.40928	.16751
C	$Y = a_0U + b_1MALE + b_2FEMALE + b_3BRAVO + b_4CHARLIE$ $+ b_5DELTA$	4	.37778	.14272
D	$Y = a_0U + b_1MALE + b_2FEMALE$	2	.35001	.12251
E	$Y = a_0U + b_1BRAVO + b_2CHARLIE + b_3DELTA$	3	.05040	.00254

[a]NLIPV = Number of linearly independent predictor vectors

NOTE: N = 786 soldiers observed for 80 lb. box baseline lift. See Table 2 for variable definitions. U is a unit vector, a_0 is the regression constant, and b_1 through b_i are raw least squares regression coefficients in the equations.

These equations were used to test specific hypotheses concerning the contribution of predictor variables to the outcomes for the 80 lb lifting task. As shown in the table above, equation B includes all specific company-by-gender variables and excludes time of day information. Equation C contains "main-effects" information for gender and company at a gross level. Equations D and E are specific to gender alone and company respectively. Comparisons between equations containing different types of information may be made to assess specific effects which may or may not have influenced the ability to lift at the 80 lb baseline. The intent of hypothesis testing is to isolate those factors which did indeed contribute to lifting ability.

Table 5 displays the F ratio results for testing various hypotheses concerning lifting ability. The first hypothesis was conducted to ensure that

Table 5

F Test Results for Assessing The Effects of Time of Day, Company Membership, and Gender Upon Lifting Ability

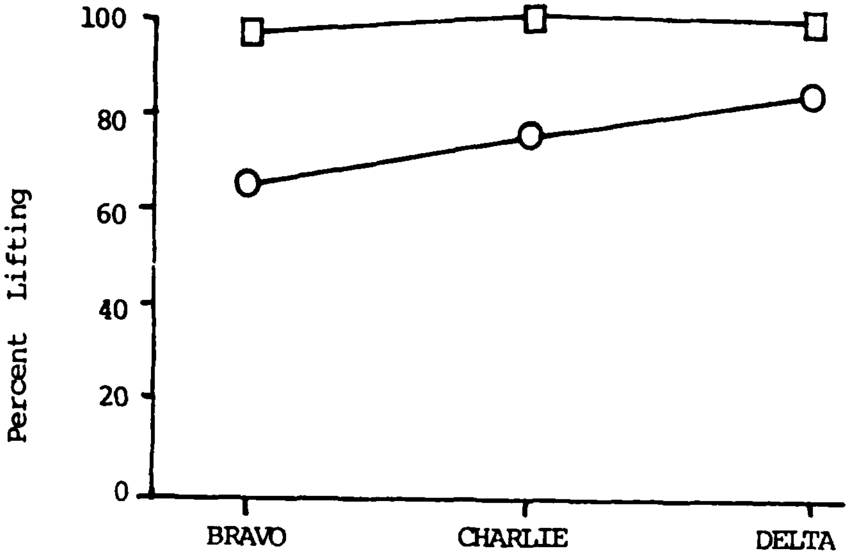
Hypotheses	Models Compared[a]	R^2_{full}	$R^2_{restricted}$	df_1	df_2	F^b
1. Substantive prediction	A vs. 0	.17113	0.	6	779	26.81*
2. Time of day effects	A vs. B	.17113	.16751	1	779	3.40 n/s
3. Test for no-interaction between gender and company	B vs. C	.16751	.14272	2	780	11.61*
4. Effects with interaction present						
Company differences	B vs. D	.16751	.12251	4	780	10.54*
Gender differences	B vs. E	.16751	.00254	3	780	51.52*
5. Main effects (Without interaction)						
Company differences	E vs. 0	.00254	0.	3	783	1.00 n/s
Gender differences	D vs. 0	.12251	0.	2	784	109.46*

[a] See Table 4 for equations
[b] F ratio statistically significant, $p < .001$, n/s = nonsignificant

an acceptable and significant level of prediction had been attained. Results indicated that lifting ability was significantly related to company-by-gender and time of day variables.

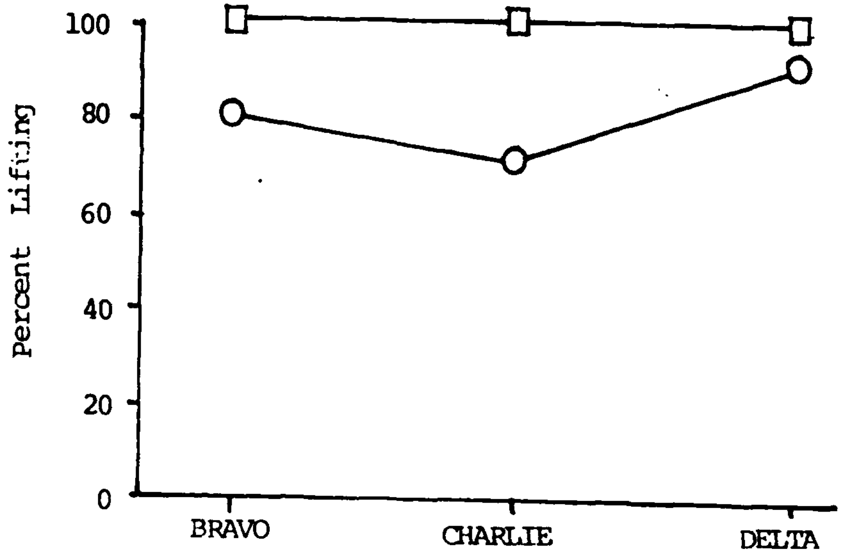
The second hypothesis tested the effect of the time of day upon lifting ability in the 786 soldier sample. Figure 1 displays the patterns for six separate groups observed in the morning and six groups observed in the afternoon.

MORNING (AM)



Company	Males □ n/N = %	Females ○ n/N = %
BRAVO	116/117 = 99.15	35/54 = 64.81
CHARLIE	93/93 = 100.00	25/32 = 78.13
DELTA	81/81 = 100.00	73/86 = 84.88
All Co.	290/291 = 99.66	133/172 = 77.33

AFTERNOON (PM)

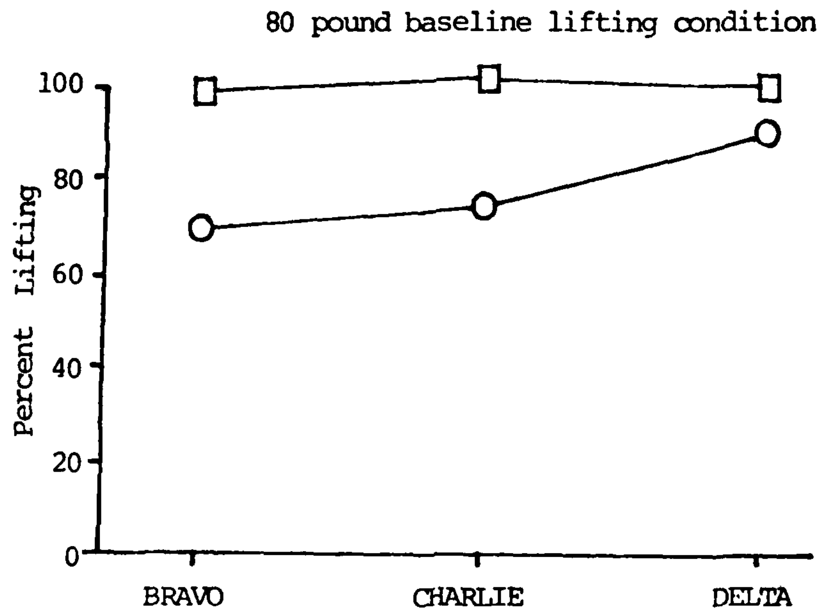


Company	Males □ n/N = %	Females ○ n/N = %
BRAVO	82/82 = 100.00	18/22 = 81.82
CHARLIE	72/72 = 100.00	22/31 = 70.97
DELTA	49/49 = 100.00	64/67 = 95.52
All Co.	203/203= 100.00	104/120= 86.67

Figure 1. Gender-by-company groups shown for the morning and afternoon lifting observation sessions. Frequencies and percentages are indicated for each of the six groups in the AM and six in the PM. Data were recorded for the 80 pound baseline lifting condition.

The second hypothesis tested whether the AM pattern was significantly different than the pattern displayed for the afternoon observation sessions. Results indicated that there were no substantial differences for the gender-by-company groups across the temporal conditions. This finding indicated that the box lifting phase of this study was not influenced by any type of fatigue factor, and that any observed differences in company and gender were consistent throughout the day. Equation B was then adopted as the full model equation.

The third hypothesis was concerned with interaction effects. Figure 2 below displays the six groups which result after collapsing across time of day conditions which were found to have no effect upon lifting capability.



Company	Males □ n/N = %	Females ○ n/N = %	Total n/N = %
BRAVO	198/199 = 99.50	53/76 = 69.74	251/275 = 91.27
CHARLIE	165/165 = 100.00	47/63 = 74.60	212/228 = 92.98
DELTA	130/130 = 100.00	137/153 = 89.54	267/283 = 94.35
All Co.	493/494 = 99.80 (Male lift capacity)	237/292 = 81.16 (Female lift capacity)	

Figure 2. Comparisons of lifting by males and females in AMFDD companies.

Specifically, the test for no interaction assesses whether lifting differences between males and females are <u>constant</u> across companies. The results for this hypothesis were significant. As shown in the figure (see Fig. 2), the DELTA company females out performed their BRAVO and CHARLIE counterparts. Whether this effect was due to a higher motivation level or to a higher level of physical conditioning can only be speculated upon. However, knowledge of interaction allows several direct comparisons between companies and gender groups. These differences are considered in the 4th and 5th hypotheses.

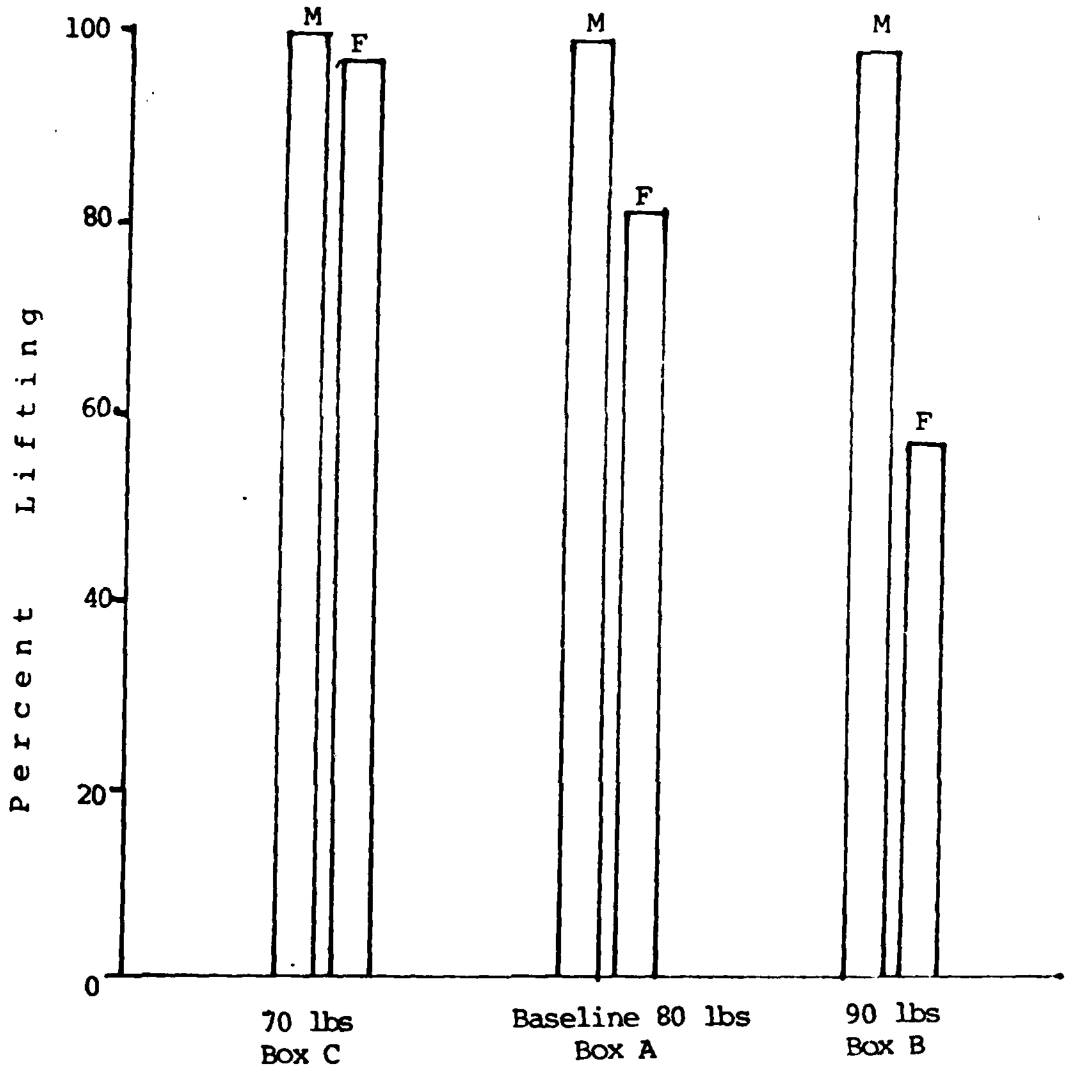
Knowledge of interaction permits a very conservative test for company differences in lifting ability. By comparing equations B and D, differing lifting capacities among companies can be tested while controlling for non-constant gender effects. The results of this test produced a ratio of F (4, 780) = 10.54, $p < .001$. A similar "conservative" test for gender effects produced a much larger F ratio, indicating that males consistently out-lifted females regardless of their company membership.

A more direct, and not as stringent test of main effects can be performed between companies. Regarding the interaction question as an atypical finding the percentages of company lifting capability shown in Fig. 2 (B = 91.27, C = 92.98, and C = 94.35) may be compared directly to arrive at an overall estimate of company differences. This is analogous to a one-way analysis of variance test. For company differences the resulting F ratio was nonsignificant. However, gender differences emerged at a very high level of effect with F (2, 784) = 109.46, $p < .001$, a very significant finding. This comparison tested the lifting capacities of males (see Fig. 2 -- 99.80) versus females (81.16 %).

In summary, companies by themselves did not exhibit differences in lifting capacity at the 80 pound level if specific gender information is not accounted for across all companies. By way of interpretation, on the average we would not expect to find radical differences among AMEDD AIT companies in terms of the ability to lift 80 pounds. This assures that these findings are representative of the AMEDD enlisted medic AIT population. However, gender differences are evident in lifting ability at 80 pounds -- regardless of whether specific gender-by-company information is available or not.

The implications of the 80 lb baseline measure results are clear. They provide a firm basis for establishing a lifting threshold for the majority of AMEDD medics. For males, 493 out of 494 could perform at the 80 lb level. However, for females, only 237 out of 292 or 81.16% could lift 80 lbs. Generally these results were found to be unbiased and uninfluenced by time of day or by company membership. Over the entire sample of 786 soldiers tested 730 or 92.88% met or exceeded the 80 lb (moderately heavy) level of lifting.

Two other weighted boxes were employed in phase I of the study (refer to Table 1). For those soldiers who could not lift the 80 lb box, the threshold weight was lowered to 70 lbs. Fifty-six cases (1 male, 55 females) were tested under the 70 lb load. The one male and 47 females did lift the 70 lb box. For a sample of 56, the regression equation patterned after Eqn D (Table 4) resulted in $\underline{R} = .055$. A corresponding test for gender differences revealed $\underline{F}(1, 54) = .16$, a nonsignificant finding. Therefore at the lower bound of lifting, no gender differences could be established. Figure 3 was constructed to demonstrate the load levels under investigation and the associated gender differences which emerge at 80 lbs but are not evident at the 70 lb level.



Total Sample Summary
N = 786

Box	Weight	Males n/N = %	Females n/N = %
A	80 lbs	493/494 = 99.80	237/292 = 81.16
B	90 lbs	485/494 = 99.18	166/292 = 56.85
C	70 lbs	494/494 =100.00	284/292 = 97.26

Figure 3. Comparison of males and females for load levels used in Phase I - medic lifting capacity. Lifting capacities are listed by percent for each load level for both male and female medics.

As shown, virtually everyone can lift 70 lbs (only 8 out of 786 could not lift at this level = 1.02%). Gender differences emerge for the 80 lb baseline.

To establish an upper bound for comparison purposes, those 730 soldiers who met the 80 threshold were tested in a 90 lb condition (Box B - refer to Table 1). Results indicated that 485 out of the 493 males could lift both 80 and 90 lbs to the truck bed. This constitutes 98.38% of the male subsample. However, for the 237 females in this group who did lift 80 lbs at the baseline, only 166 or 70.04% were capable of lifting the 90 lb box, a difference of 28.34% from the males. A regression equation (same form as EQN D - Table 4) for gender variables resulted in $\underline{R} = .427$. When tested against a correlation of zero, significant gender differences again emerged with $\underline{F}(1,728) = 162.42$, $\underline{p} < .001$.

In summary, out of 786 soldiers tested, 651 could lift at least 90 lbs; however, this composite figure is made up of 99.18% or 485 out of 494 males as compared to 56.85% or 166 out of 292 females -- a difference of 42.33% at the 90 lb load level.

Phase I Conclusions

The inferences for this phase of the study may be summarized by the following example. For a hypothetical company of 100 soldiers composed of 50 males and 50 females, we would expect the following patterns to emerge for required lifting capacity at certain load levels.

1. At 70 lbs almost all, 99 out of 100 soldiers could perform lifting required. Only one, probably a female, would not be able to do the task.

2. At 80 lbs about 91 out of the 100 soldiers would meet the lifting requirements (50 out of 50 males, 41 out of 50 females). This 9 soldier deficit could be made up for in two ways. Nine more males could be added at 99.80% lift capacity; or 11 more females could be added at 81.16% lift capacity (i.e. 11 females x .81 capacity = 9 soldiers lifting at 80 lb requirement). While a statistical difference exists at the 80 lb level, this may not represent a practical difference in medical task performance.

3. At 90 lbs only about 77 soldiers would meet the lifting requirement (at least 49 out of 50 males, at least 28 out of 50 females). To regenerate lifting capacity at a required level of 90 lbs a deficit of 23 soldiers would need to be made up for. If males were used, 24 males would be required at 98.18% lift capacity (i.e. 24 males x .9818 is approximately 23). However, if females were added to make up for the deficit, 40 would be required at 56.85% lifting capacity (i.e. 40 females x .5685 capacity is approximately 23 more soldiers lifting above the 90 lb threshold). This indicates that there may be both a statistical and practical difference at the 90 lb load level.

In summary:

At 70 lbs a loss of 2.74% lift capacity is due to females; no loss for males.

At 80 lbs the loss of lifting capacity is 2/10th's of 1% for males; and a loss of 18.84% for females.

At 90 lbs the loss of lifting capacity is .82% for males, and a loss of 43.15% for females.

Medic Performance Capability - Field Environment Tasks - Phase II

Those soldiers who had lifted at the 80 pound baseline but were unable to lift in the 90 pound condition (n = 79 -- see Table 1) were further assigned to a field task performance condition consisting of three medical related tasks. The performance based tasks included:

a. One man evacuation, distance of 20 meters, utilizing the drag method.

b. Survey of a casualty, in the prone position.

c. Two man evacuation, distance of 50 meters, utilizing the cross arm carry method.

The 79 medic subsample consisted of 8 males and 71 females. Each medic was tested in all three task conditions. Test scores were recorded as either "go" or "no go". Test results indicated that all medics, both male and female, successfully accomplished task "a" and "b" to standards. For task "c", 77 of the 79 received a "go" score; two females did not complete the task sequence requirement. In all, phase II consisted of 237 field task trials (79 soldiers x 3 test items). Table 6 displays the descriptive statistics for task performance trials and the regression results for

Table 6

Field Task Performance Trial Scores:

Frequencies and Regression Results for Males and Females

	Field Task Scores		
	No go	Go	Total
Males	0	24	24
Females	2	211	213
Total	2	235	237

(Performance scores coded 1 if go, 0 if no go)

$$Y_{\text{performance score}} = a_0 U + b_1 \text{MALE} + b_2 \text{FEMALE}$$

$R = .03097$

$R^2 = .00096$

$F(1,235) = .23$, nonsignificant

testing the hypothesis of gender differences. As shown, no evidence could be found for performance differences between male and female medics.

In terms of loss of task performance capacity, males experienced no loss while 2.82% (2 out of 71 females) capacity loss was due to females.

Phase III - Comparison of Lifting and Performance Capacities

As demonstrated by phase I of the study, gender differences emerged at the 80 pound load level and drastically reduced lifting capacity at the 90 lb load level. However, no gender differences were detected at the lower load level of 70 lbs (see Figure 3 for a summary). In phase II gender differences did not emerge for performance across three medical tasks. Based upon these two findings, the load parameters established in phase I may be used to assess the "load requirements" for the performance tasks in phase II. If the performance tasks were correctly classified as heavy (from 81 up to 100 lbs) then we would have expected a female loss of between 18.84% and 43.15% as stated in the phase I conclusions. This level of capacity loss did not emerge for the performance tasks used in the study. The capacity loss for phase II appeared to be more closely aligned with the 70 lb load level, viz. 2.82% capacity loss phase II versus 2.74% capacity loss for phase I. Based upon the combined results presented above, it is recommended that the three performance tasks would appropriately be classified as moderately heavy (up to and including 80 lb.).

This recommended classification is based upon 1) the evidence obtained from a controlled study which established the gender specific load level parameters for enlisted medics by examination of 786 AIT soldiers; and 2) upon the intensive examination of medic task performance in a field environment.

Reference Notes

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U.S. Department of Labor Selected characteristics of occupations defined in the dictionary of occupational titles. Washington, D.C., 1981.

Weighted boxes used in this study were fabricated by the Brooke Army Medical Center (BAMC) building and maintenance group and met specifications as outlined by the Criterion Performance Testing Unit, Advanced Research Resources Organization (ARRO), 4330 E. West Highway, Bethesda, MD 20814.

and the gender measure. On the average, males appeared to lift at the

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