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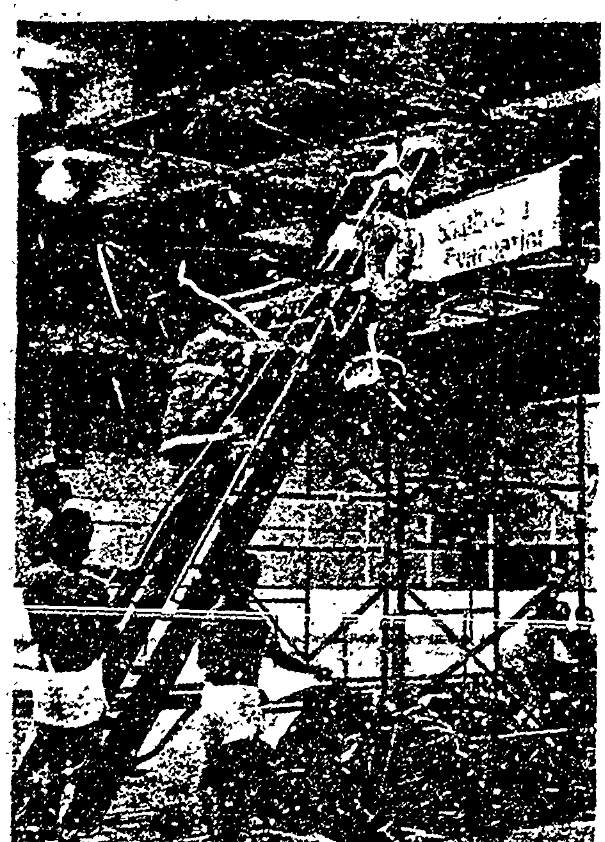
Development of Minimum Physical Fitness Standards for the Canadian Armed Forces: Phase III

DSS/DND Contract W8477-7-SC02/01-ST
DEPARTMENT OF PHYSICAL EDUCATION AND RECREATION

March 1988



by
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DEVELOPMENT OF MINIMUM PHYSICAL FITNESS STANDARDS

FOR THE CANADIAN ARMED FORCES:

PHASE III

submitted by

SCHOOL OF PHYSICAL AND HEALTH EDUCATION
DEPARTMENT OF MECHANICAL ENGINEERING

QUEEN'S UNIVERSITY AT KINGSTON

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PREFACE

This study was the third phase of a project to assist in the development of a set of minimum physical fitness standards which would be commensurate with performance of common military tasks. The specific purpose of this phase was to validate the minimum physical fitness standards for younger women and older men and to develop a standard for older women. In addition a sub-study was to examine the importance of the restriction of older subjects to 90% of their maximal capacity. With the permission of the CF, the common tasks were modified substantially in order to create one person simulated tasks that were reliable. The tasks performed were operationally defined as: land evacuation, sea evacuation, low-high crawl, entrenchment dig and sand bag carry. The physical fitness tests selected for comparison included the EXPRES test battery of sit-ups, push-ups, maximum grip strength and predictive oxygen consumption as well as laboratory measures of the incremental lifting machine test, flexed arm hang and endurance grip.

The study was conducted at Queen's University with 59 younger women, 28 older women and 62 older men tested over a three week period. Subjects were selected on the basis of oxygen consumption values from EXPRES such that there was an equal number selected from each quartile of aerobic fitness.

Correlations between EXPRES and laboratory tests to military tasks revealed that the underlying fitness components differed between groups with a greater difference between men and women than between younger and older women. In the stepwise regression analysis the variance in task performance scores could be explained 8% to 64% depending on the task and group. On the average, 39% of the variance in task performance data could be explained with fitness measures from EXPRES and additional laboratory tests. This evidence was sufficient to conclude that fitness is important for task performance and therefore the development of a minimum standard seemed appropriate. As task performances could not be predicted by EXPRES, it was necessary to develop an empirical model to determine 'passers' and 'failers' for younger and older groups. In Phase II the data for men and women were combined to develop a cumulative frequency with the passing criteria set at the time at which 75% of the individuals completed the task. This procedure was repeated for men and women ≥35 years but the heart rate restriction of 90% maximum forced a 32% adjustment in task completion times. This adjustment was validated in a sub-study of 19 subjects who were asked to perform the entrenchment dig at both 90% and 100% effort. Once again the 75 percentile was used to separate 'passers' from 'failers' and the minimum physical fitness standards were developed on the passing group. Additional comparisons were made using discriminant analysis and differences between means to examine the passing and failing groups. As the underlying fitness variables differed between groups, it was necessary to use only those fitness measures where there was a significant relationship to task performance to develop the minimum standard. The minimum fitness standard was established as the level achieved by 95% of the passers for each task and group. By inference a number of false negatives was controlled at 5% in that the minimum fitness standard was the point at which 95% of the passing group attained the fitness score. These scores where then compared using a cross-tabulation for all tasks to see the chance of falsely classifying a subject as a failure. Finally, minimum fitness scores were compared to normative data tables to examine the impact of standards by gender and age. The minimum standards are based on two samples from military personnel of wide fitness levels (Table A18). We recommended that EXPRES standards could be set based on the evidence from this study and the previous phases for each of the four sub-groups. These standards reflect the population studied and Table A18 reflects the judgments made between the two sample populations. In addition, we recommend that the simulated tasks, as indicated in the present task protocols, be continued rather than the actual tasks themselves in that they are one person tasks and more reliable. For safety reasons, it is also recommended that subjects ≥35 years not be permitted to exceed 90% of their maximum heart rate reserve and that this safety limit be constantly monitored and enforced throughout the performance of the task unless sanctions are considered, in which case medical personnel must be present for all out exertion. Finally, it is recommended that a technology transfer phase be initiated which would permit the Canadian Forces to continue to monitor changes in task performance with fitness changes. By continuing to collect data at a common site, it will be possible to expand the type of analysis used and allow the Military to improve long range planning for tests and tasks.

In this report Section A is a summary of the findings from all aspects of the study. This includes the essential description of the objectives and workplan, descriptive results, inferential results, implications, discussion, conclusions and recommendations. Contained within the conclusion and recommendation section is Table A18 which is a recommended fitness standard based on these three phases of data acquisition. The detailed experimental reports are contained in Section B, individualized by each task. These reports describe the fitness measurements and determine their relation to performance for each of the five tasks studied. Section C of the report presents, from a more theoretical perspective an alternate method of data analysis using probability theories. This method of analysis would permit the use of a combination of fitness scores in determining 'passers'. In addition the probability of successful task performance could be evaluated for each task and group, thus making the standards more flexible for different populations or time periods; more importantly, perhaps, it would permit a low measure in a given variable to be offset by a high score achieved in others.

This seems important, particularily in light of the facts which clearly establish the solution between fitness variables and performance. However, it must be appreciated that before this probability approach can be validated and this accepted, this proposed model needs substantial additional data to give it the needed statistical power. The final section of the report includes appendices which document the protocols and raw data from this phase of the study.

This project was truly a team effort. I wish to acknowledge the impetus and guidance of Lieutenant Colonel Robert Swan, Major Wayne Lee and Captain Winson Morrison (DPERA). The principal investigators of Drs. George Andrew, Tim Bryant and John Thompson have always formed a cohesive unit which makes these undertakings efficient and enjoyable. The daily management of the data acquisition and analysis phases were under the leadership of Sheryl French and Mary Byrnes with continuing support throughout the contract by Shelly Drake. Many capable research assistants, namely Cheryl Johnson, Kathy Moore, Gary Osborne and Drew Stephens as well as other students also assisted with the extensive data acquisition phase. In addition I wish to acknowledge the support of the School of Physical and Health Education and Queen's University personnel who cooperated with the effort of the Ergonomics Research Laboratory. To all of these people I wish to convey my thanks and gratitude for your continued enthusiasm and support.

J.M. Stevenson, Ph.D.
March 15, 1988

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SECTION A

THE SUMMARY REPORT

A1 DIRECTIVE OF THE CONTRACT

A1.1 Statement of the Problem

The Canadian Armed Forces wish to determine a minimum physical fitness standard for all military personnel, regardless of trade classification, age or gender. Various NDHQ directorates determined seven common military tasks which all CF personnel might be expected to perform in time of emergency. This rationale was then used as the basis to establish bona fide occupational requirements in compliance with the Canadian Charter of Human Rights. To this end, the Ergonomics Research Laboratory at Queen's University has been contracted to assist with the study, initially under the direction of the Defense and Civil Institute for Environment Medicine and for this contract under the leadership of the Department of Physical Education and Recreation (DPERA).

A1.2 Review of Previous Contracts

To assist in the development of physical fitness standards for the Canadian Forces, three phases have been conducted by Queen's University (Table A1). Within each phase refinements have been made in task protocols and subjects studied, as well as statistical approaches and comprehension of the problem.

In the first phase, five of the actual common tasks were examined on the basis of speed of completion only, and compared to EXPRES, the fitness test battery presently in place in the Canadian Forces. In this first phase only data for young men were appropriate for analysis. An empirical model was developed whereby a minimum fitness standard could be determined for the passing group. The major shortcoming identified in this phase was the unreliable task protocols.

As a result, in Phase II operational definitions and revised protocols

Table A1 Phase of research and number of subjects studied in each phase.

Group	Phase I 1985 (# of subjects)	Phase II 1986 (# of subjects)	Phase III 1987 (# of subjects)
Young Men < 35 years	99	71	--
Older Men ≥ 35 years	--	41	62
Young Women < 35 years	--	88	59
Older Women ≥ 35 years	--	--	28

Subjects 35 years of age and older were restrained to 90% maximal capacity as a safety restriction in compliance with ethics and the American College of Sports Medicine guidelines.

were developed for each of the most demanding tasks. Samples of younger men, older men and younger women were assessed on the refined task protocols, EXPRES and laboratory tests. A slightly modified protocol was established for older subjects equal to or greater than thirty-five years (≥ 35) based on an ethics and safety restriction which complied with the American College of Sports Medicine guidelines. The empirical model was developed further to maintain a common task requirement for each of the three sample populations. The main observation from this phase was that, although the task requirements were the same for all three groups of younger men, older men, and younger women, the underlying fitness parameters which related to task performance differed for each group. Based on results of this phase, it seemed possible to establish the minimum fitness standard; using a representative and equal sample of men and women and based on those subjects who passed each task. However, additional recommendations were made to provide a more global approach to the problem.

A1.3 Statement of Purpose and Objectives

The specific purpose of this contract was to validate the fitness standards suggested for women and older men in the Canadian Forces. Within this contract it was proposed that the same operational definitions as used in Phase II be repeated with a different population. The empirical model developed in previous contracts was a representative sample from each of the four groups, namely younger men and women, and older men and women. Therefore this approach was to be repeated along with any additional new approaches which could be used in the development of a minimum physical fitness standard. More specifically, the objectives of this study were:

1.3.1 to develop a minimum physical fitness standard for younger women, based on an empirical model with a common task criteria;

1.3.2 to develop a minimum physical fitness standard for older men, based on an empirical model with a common task criteria; and,

1.3.3 to develop a minimum physical fitness standard for older women, based on an empirical model using common task criteria.

Within this contract, a small but vital sub-study was conducted to examine the importance of the restriction of older subjects to 90% of their maximal capacity. The specific objective was:

1.3.4 to examine the impact of a 90% restriction of task performance on older subjects.

A2 TASK CRITERIA

A2.1 The Identified Common Military Tasks

Seven common military tasks which all CF personnel might be expected for perform in time of emergency were identified and defined by various NDHQ directorates with the studies conducted under the auspices of DPERA. The original definitions of the common tasks are presented in Appendix A. The tasks were:

i) operate one's personal weapon (shoot-to-live test);

ii) function effectively in nuclear biochemical warrare (NBCW) clothing environment;

iii) perform first-aid and casualty evacuation:

   a) land evacuation

   b) sea evacuation;

iv) perform firefighting duties;

v) execute survival search and rescue techniques;

vi) perform general security duties:

   a) march eight kilometres

   b) entrenchment dig

   c) lift and carry sandbags

   d) low and high crawl

   e) rush and shoot with weapon;

vii) live and work in NBCW clothing, as applied to condition vi).

Not all of these tasks require high physical fitness standard, while others are physically demanding, but not as exhaustive as those selected for the original task battery (see Phase I Report for selection process). Still other common tasks, such as functioning in NBCW clothing, were considered too complex for an original assessment of EXPRES tests but are even more limiting because of bulkiness and lack of heat transmission. Hence, the select n process for which tasks were to be evaluated was based on literature, scientific testing, or ease of data acquisition (Table A2).

A2.2 Operation Definitions of Task Criteria

In order to develop reliable task definitions equipment was constructed to allow each task to be performed single-handedly. For example, both the sea and land evacuation tasks were restructured to be one-person tasks (i.e., wheels on the land stretcher; a push-skid for the sea evacuation stairs stretcher). Other tasks were altered to ensure standardization of the tasks for all subjects (i.e., the entrenchment dig became a task of removing crushed rock from a box to one of the same dimensions). Each task underwent serious evaluation and repeatability testing before the present five task battery was developed for Phase II and Phase III. The Pearson correlation coefficients on test-retest scores for each operational definition varied from r=.93 to r=.99.

A2.2.1 Sea evacuation. This task simulated casualty evacuation during a fire on board ship. Working against time, the subject was required to carry an 80 kg stoker stretcher 12.5 m to the base of a flight of stairs. The subject then pushed a skid carrying one subject's share of the mass up and down a flight of ship staircase, returning the stoker stretcher to the starting point.

A2.2.2 Land stretcher evacuation. This task was designed to simulate a land evacuation of a casualty on a stretcher over a distance of 750 m. A subject carried half of an 80 kg mass on a normal stretcher with wheels attached at one end, as quickly as possible over a distance of 750 m. (The original 1 km task was reduced to 750 m as the correlation coefficient was r=.94 between the times for these distances.)

A2.2.3 Low-high crawl. This task simulated conditions of self protection when moving in front of enemy fire. Each subject was to perform a

Table A2 Identification of selected emergency tasks and fitness tests used in the development of minimum physical fitness standards for the Canadian Armed Forces.

Item	Description of Item
Emergency Tasks	1. Land Evacuation 2. Low-High Crawl 3. Sea Evacuation 4. Entrenchment Dig 5. Sand Bag Carry
Fitness Tests	1. EXPRES test a) Grip strength b) Oxygen consumption c) Push-ups d) Sit-ups 2. Additional Laboratory tests a) Flexed arm hang b) Endurance grip c) Free-style ILM

low crawl (all body parts close to the ground) for 30 m by moving under restraining barriers; turn 180 degrees, and perform a high crawl (on hands and knees) for 45 m. Throughout the task the subject wore a helmet and carried a facsimile of the FN/C 1 rifle. Time to complete the task was the primary performance criterion.

A2.2.4 Entrenchment dig. This task intended to simulate self-protection in face of enemy fire by digging an entrenchment. Each person dug a one-person entrenchment 1.82 m long, .61 m wide, and .46 m in depth. The entrenchment task entailed shoveling 1 m^2 of crushed rock dampened only to prevent dust, from one box to another of similar dimensions in the shortest period of time.

A2.2.5 Sandbag Carry. This task was to simulate self-protection or protection of others from natural elements. The subject was asked to move the maximum number of sandbags a distance of 50 m in ten minutes. Each sandbag had a mass of 20 kg and the performance score was the number of bags moved.

A2.3 Fitness Tests

Two sets of laboratory tests were conducted, the EXPRES fitness test and additional laboratory tests (Table A2). The EXPRES test, which is the standard test battery currently in use in the Canadian Forces, was administered by trained CF personnel prior to the present contract. Results of the oxygen consumption scores were used to select subjects equally distributed in each quartile of the fitness range. The battery of tests will be explained below.

2.3.1 Oxygen consumption measure. This EXPRES item entails a sub-maximal step test performed at a set cadence and workload. As there is a linear relationship between heart rate and oxygen consumption, this test is used to predict aerobic capacity.

2.3.2 Maximum grip strength. In this EXPRES item a hand held dynamometer is used to measure maximal grip force. The subject performs two maximal grip tests with each hand and the better test result for each hand is summed to provide a maximum grip strength score.

2.3.3 Pushups. This is an EXPRES item which uses arms at shoulder width and toes as a fulcrum to execute as many pushups as possible until exhaustion.

2.3.4 Situps. This EXPRES item requires the subject to execute as many situps as possible in one minute from a posture of knees bent, hands behind the head and toes held down.

A2.4 Laboratory Tests

In addition to the EXPRES, these other laboratory test items were included, based on consistent correlations in Phase I and Phase II.

2.4.1 Flexed arm hang. The body mass was supported at a fixed hanging point with bent arms, chin above bar level, until fatigue.

2.4.2 Endurance grip. The subject was asked to hold a 20 kg grip force as long as possible for each hand.

2.4.2 ILM freestyle lift. Subjects were asked to lift as much weight as possible to a height of 1.8 m. Subjects were allowed to stop during the lift; however, they were not permitted to execute a second attempt within the same lift cycle, or to exceed 10 seconds in total lift time.

A3 METHODS

The specific test items carried out were described above. This section describes the design of the testing and matters related to data processing.

A3.1 Testing Location

In previous contracts, the Ergonomics Research Laboratory visited CF bases in Kingston, Borden, Ottawa and Halifax. The third phase of testing was conducted in a common location in the Jock Harty Arena of Queen's University in Kingston, Ontario, during a three-week period, from August 4th to August 21st, 1987. Subjects were transported to Kingston from various CF Bases, most frequently CFB Trenton, Kingston and Ottawa, as well as NDHQ in Ottawa.

A3.2 Subject Selection

For the third phase of the contract, sample populations of younger women, older women and older men, were selected by DPERA. A minimum of twenty subjects per group from each fitness quartile, based on aerobic capacity were requested for the study. For older women ≥ 35 years of age forty subjects were requested; half above and below the 50th percentile. A distributed but random sample population was requested to ensure that the minimum fitness standards would not be skewed unduly high because of a more fit sample. Hence by the end of Phase III, 2 separate samples of men ≥35 (Phase II and III) would have been tested to assist with the development of a fitness standard. Only one sample of women ≥35 (Phase III) were investigated due mainly to the difficulty in acquiring subjects.

A3.3 Testing Sequence

Upon arrival at Queen's University, subjects were given an initial briefing by an officer from DPERA and the project manager from Queen's University. Subjects were then provided with a short tour of the testing facilities, shown accommodation, and provided with lunch. Upon return, a formal briefing on the purpose of the study was held, which addressed such matters as a review of the test and task batteries, assurance of confidentiality, safety and general procedures. Subjects were divided into small groups and rotated in a circuit through all six stations. (See Appendix B for subject information booklet.) Only one test item was performed in each half-day, in order to reduce and control levels of fatigue. Each testing station had specific personnel who remained at that station throughout the testing week in order to control supervisor impact. Leaders at each project station used a written manual of protocol for each task, read the protocol to subjects, and provided demonstrations and practice time prior to the task. Leaders tried to remain consistent in encouragement, reinforcement and protocol requirements.

Subjects who were thirty-five years and older were required to wear a heart rate monitor which was programmed to signal when the heart rate exceeded 90% of predicted maximal using the formula: 90% HR =.9[(220 - age) -70 bpm]+70 bpm. Older subjects were required to stop whenever the heart rate monitor exceeded 90% maximal capacity and rest until the heart rate returned to the target zone. This protocol was in compliance with the American College of Sport Medicine guidelines on safety precautions when subjects are being tested without direct medical supervision or a medical history available.

A3.4 Data Processing

After each testing day the station leader entered raw data on each subject onto disk using a Zenith micro-computer and Lotus software. Data, once entered, were then checked by the project leader for errors in data input. Data files were merged, processed and transferred to the mainframe for statistical analysis.

A3.5 Statistical Analyses

The statistical analyses were performed within SPSSX with certain graphing routines performed within Lotus and Sigmaplot. Figure A1 is a flow diagram of the analytical steps involved.

A3.5.1 Graphs of raw data. Graphic Comparisons were made between the three groups in performance of various military tasks as well as EXPRES and laboratory tests.

A3.5.2 Simple correlations. Pearson correlation coefficients were derived between tasks, EXPRES scores and other test variables to identify the relationship between fitness test variables and complex military tasks. Because of the number of variables being assessed, a probability level of .001 was identified as significant.

A3.5.3 Multiple correlations. Multiple correlations based on backwards stepwise regressions analysis were performed on each task to identify which fitness variables combined to measure the relationship between many variables and one task.

A3.5.4 Determination of passing criteria. In Phase III the sample was predominantly older subjects, all of whom were restricted in task performance by a safety constraint of 90% maximal heart rate. To determine the passing group equal samples of men and women were selected and the 75th percentile was identified as the passing criteria. To determine if this correction factor was appropriate between older and younger groups, a sub-study with 19 subjects was performed to compare restricted and unrestricted protocols. For younger women, the same passing criteria as in Phase II was used.

A3.5.5 Discriminant Analysis. Discriminant analysis was performed to compare passers and failers on each task based on fitness variables. This discriminant analysis identified two

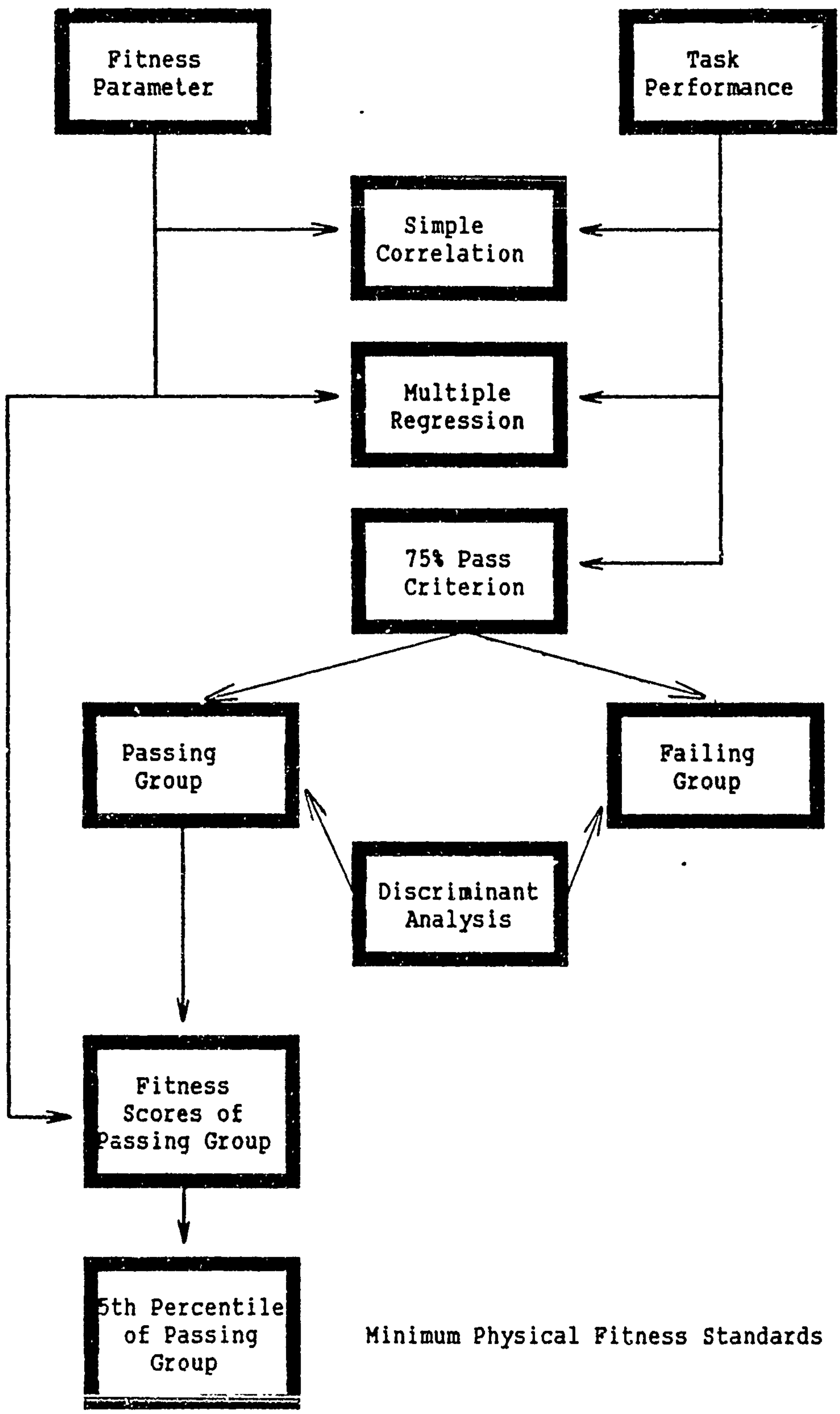

Figure A1. Flow diagram of inferential results used in the development of Minimum Physical Fitness Standards points, namely when a fitness variable was able to discriminate between passers and failers, and secondly, when a reliable difference existed between the means of the passing and failing groups in the predicted direction.

A3.5.6 Establishment of passing criteria. The EXPRES variables for each task were then examined for reliable relationships using: simple correlation; stepwise regression; discriminant analysis; and, reliable differences in passing and failing group means. The passing scores for each group were then converted to normalized z-score values in order to determine the point at which 95% of the subjects would have passed the task. In other words, the lowest 5% of the fitness scores obtained by passing subjects was taken to be the minimum requirement to perform the task.

A3.5.7 Prediction of passing and failing. The overall impact of these minimum stand.rds was examined by cross tabulation of predicted versus actual performance to determine the accuracy of prediction of passers and failers based on these standards.

A3.5.8 Comparison to normative data. The standards proposed were then compared to the normative data for military and Canadian population to see the impact of the proposed fitness level to all military subjects based on age.

A3.5.9 Probability analysis. Because these standards are not flexible or transferable from one sample to another, a more universal analysis, namely a probability analysis was performed. Although limited by sample size, probability tables were created for fitness tests and task performance. From these probability values it would be possible to upgrade the standards based on stronger rationale, thereby making them more universally accepted.

A4 DESCRIPTIVE RESULTS

The data below are presented under three headings. In this section each component is dealt with separately without reference to statistical approaches. In addition, each section reviews the results from the previous two samples for comparison.

A4.1 Physical Characteristics of Subjects

The sample consisted of a total of 149 subjects comprised of 59 women <35 years, 28 women ≥35 years and 62 men ≥35 years of age. Means, standard deviation and ranges of all subjects in Phase III are divided by age and gender in Table A3. The characteristics of age, height and weight of the sample population were representative of military normative data. A significant difference was noted between height and weight variables across gender, though not in regard to age. The younger women in Phase III were similar in age, height and weight characteristics to other phases. However, the older men and women categories contained a subject pool approximately three years older than the previous phase and older women were 5.4 kg heavier than the previous sample.

A4.2 Sample Distribution by EXPRES

The distribution of the subjects on the basis of EXPRES percentile scores is shown in Table A4 with descriptive data in Figure A2. Subjects had been requested at random but within quartiles of fitness scores based on oxygen consumption values. For women under thirty-five years, the sample was evenly distributed in oxygen consumption but skewed positively in combined grip and negatively in push-ups. However, for older women there was a preponderance of subjects who fell in the excellent category, in oxygen consumption and grip, although some subjects were distributed in lower fitness levels. The sit-up scores were well distributed, but push-ups were negatively skewed. For older

Table A3 Summary of Physical Characteristics of the Sample by Age Group and Sex.

	Age (yr)	Height (cm)	Weight (kg)
Women < 35 years n= 59			
Mean	25.9	165.1	63.8
SD	3.6	6.4	8.4
(min-max)	(18-34)	(152-180)	(49-91)
Women ≥ 35 years n= 28			
Mean	38.2	165.3	67.3
SD	2.0	6.2	9.7
(min-max)	(35-44)	(151-175)	(52-92)
Men ≥ 35 years n= 62			
Mean	42.5	175.4	80.3
SD	4.8	5.7	10.1
(min-max)	(35-53)	(164-189)	(63-112)

Table A4 Population Distribution by EXPRES Percentiles based on Military Normative Data. Values indicated are the counts observed in each category.

Test Variables	Women < 35 Years	Women ≥ 35 Years	Men ≥ 35 years
OXYGEN CONSUMPTION (ml/kg/min)			
Excellent	11	12	27
Good	14	6	4
Average	11	4	9
Below Average	12	3	15
Poor	11	3	7
COMBINED GRIP (kg)			
Excellent	32	1	29
Good	14	10	10
Average	4	4	14
Below Average	7	4	6
Poor	2	9	4
SITUPS (no.)			
Excellent	17	6	22
Good	6	5	15
Average	10	9	15
Below Average	11	6	3
Poor	15	2	8
PUSHUPS (no.)			
Excellent	4	1	23
Good	0	1	13
Average	5	2	10
Below Average	8	4	10
Poor	42	20	7

Excellent - 81-100 %ile
Good - 61-80 %ile
Average - 41-60 %ile
Below Average - 21-40 %ile
Poor - ≤20 %ile

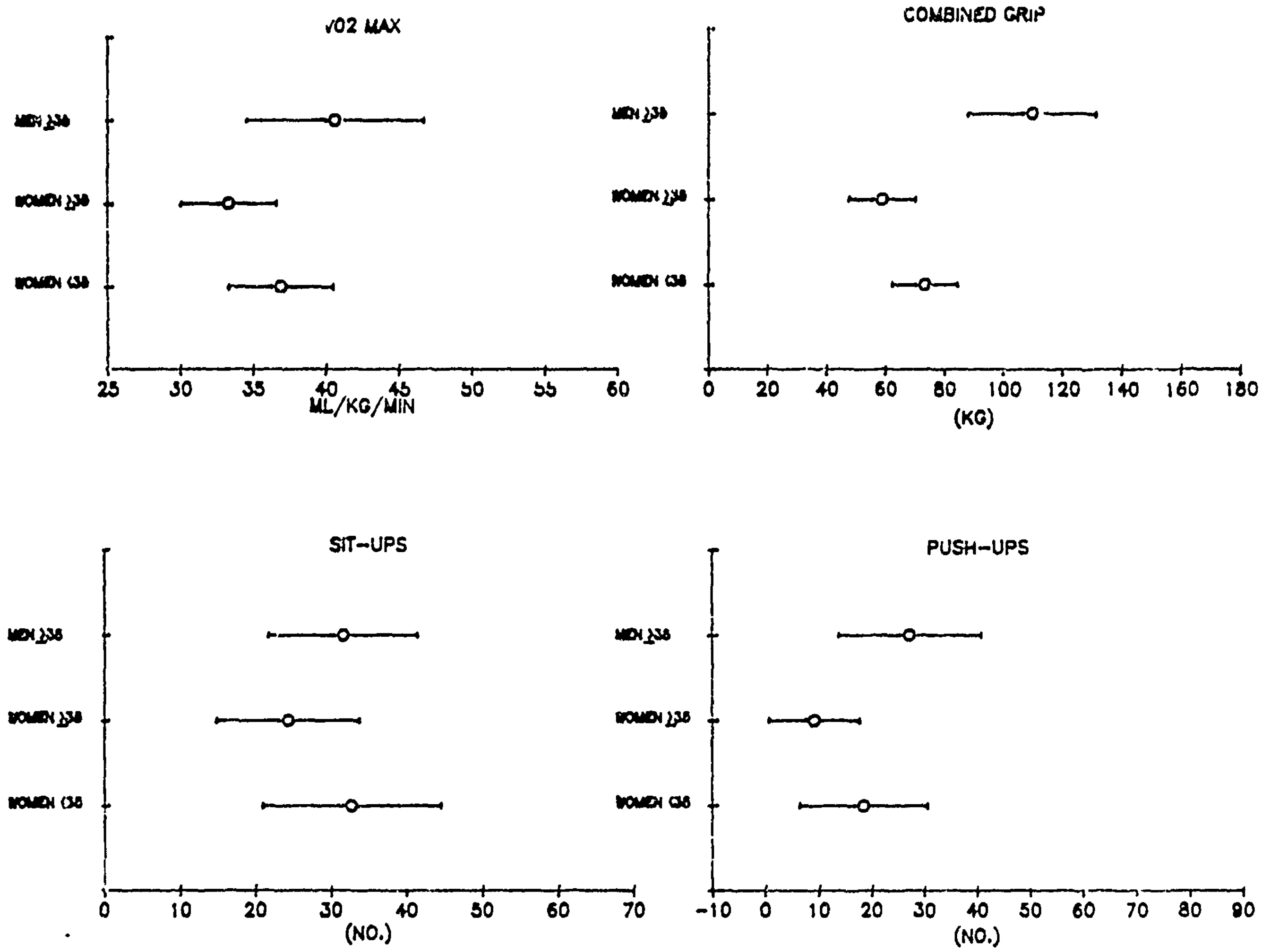

Figure A2. Graphic display of EXPRES scores of the sample by age and group. The o represents the mean scores and the bar represents one standard deviation.

men there was a large grouping at excellent and below average categories for oxygen consumption, but subjects were skewed positively for all other fitness categories.

There would be a natural tendency for more fit subjects to volunteer for physically demanding tasks. Unfortunately, this natural selection process tended to render higher prediction values of MPFS. As the subjects were selected based on oxygen consumption values, it was not possible to account for grip, push-up or sit-up scores. If a larger sample were selected for study then it would be anticipated that all EXPRES variables would become normally distributed.

The push-up data were skewed toward the poor category for both younger and older women. Between Phase II and Phase III, a push-up protocol was implemented for women to be the same as men's push-up. When comparing data from Phase I and II, where push-up scores were excellent and normally distributed respectively using the knee style push-up, Phase III data would indicate that the preponderance of poor push-up scores were highly questionable for establishment of a standard.

The EXPRES data for the three groups are plotted for comparison (Figure A2) and the actual EXPRES scores by age group and sex for the sample population are presented in Table A5. With all EXPRES variables older men have higher scores than younger women who also have higher mean scores than older women. This tendency would be expected based on the normative data by gender and age. The only variable which did not follow this trend was sit-ups, where younger women had a slightly higher mean score than older men. Both sit-ups and push-ups would be naturally adjusted by one's own body weight hence the impact of body size was not as obvious. This was not evident in the push-up scores, where women were asked to execute a different push-up between Phase II and Phase III. The drop-off in MVO_2 was expected by gender and age,

Table A5 Summary of EXPRES scores of the sample by age group and sex.

	Predicted VO2MAX	Combined Grip (kg)	Situp (no.)	Pushup (no.)
Women < 35 years n= 59				
Mean	36.9	73.2	32.7	18.4
SD	3.6	11.2	11.8	12.1
(min-max)	(30.4-50.2)	(43-98)	(7-59)	(0-70)
Women ≥ 35 years n= 28				
Mean	33.3	58.6	24.3	9.1
SD	3.3	11.4	9.5	8.6
(min-max)	(27.5-39.8)	(37-80)	(4-42)	(0-35)
Men ≥ 35 years n= 62				
Mean	40.6	109.5	31.6	27.1
SD	6.1	21.8	9.9	13.5
(min-max)	(30.4-57.8)	(14-159)	(8-62)	(5-81)

and combined grip scores, responded to body mass as well as age.

A4.3 Summary of Laboratory Tests

Based on previous reports, three additional laboratory tests were included in the test battery; namely, flexed-arm hang, combined endurance grip, and free-style maximal Incremental Lifting Machine (ILM) lift. These data are plotted in Figure A3a-c and reported in Table A6. In all cases older men had higher scores for all three variables than younger and older women. Younger women had higher scores than older women on flexed arm hang and ILM lift; however, endurance grip was greater, although not significant, for older women. When comparing tests across groups and years, the sample of younger women for Phase III were higher on all test categories than women from the previous phase. This result paralleled the EXPRES data across younger women. The opposite effect was true for older women in that the small sample (n = 8) in Phase II were elite women, whereas this sample was larger (n = 28) and more widely distributed. Likewise, the older men were less proficient at flexed-arm hang and combined grip in comparison to the previous year. This followed the profile of older men on the EXPRES test, where all scores were lower except for maximal combined grip.

The ILM test could not be compared between phases because a freestyle ILM lift was a change in protocol incorporated in this Phase III. A freestyle lift was selected as this test is being considered in recruiting stations as an indicator of strength. For all groups the lift scores were higher than previous years. This was to be expected as subjects were permitted to stop (usually at the wrist change-over point) and continue upward to 1.8 m. The difference in ILM scores from Phase II to Phase III for younger women, older women and older men, were 7.0 kg, 4.1 kg, and 7.3 kg, respectively. The higher scores on ILM tests across all groups, indicated that the previous

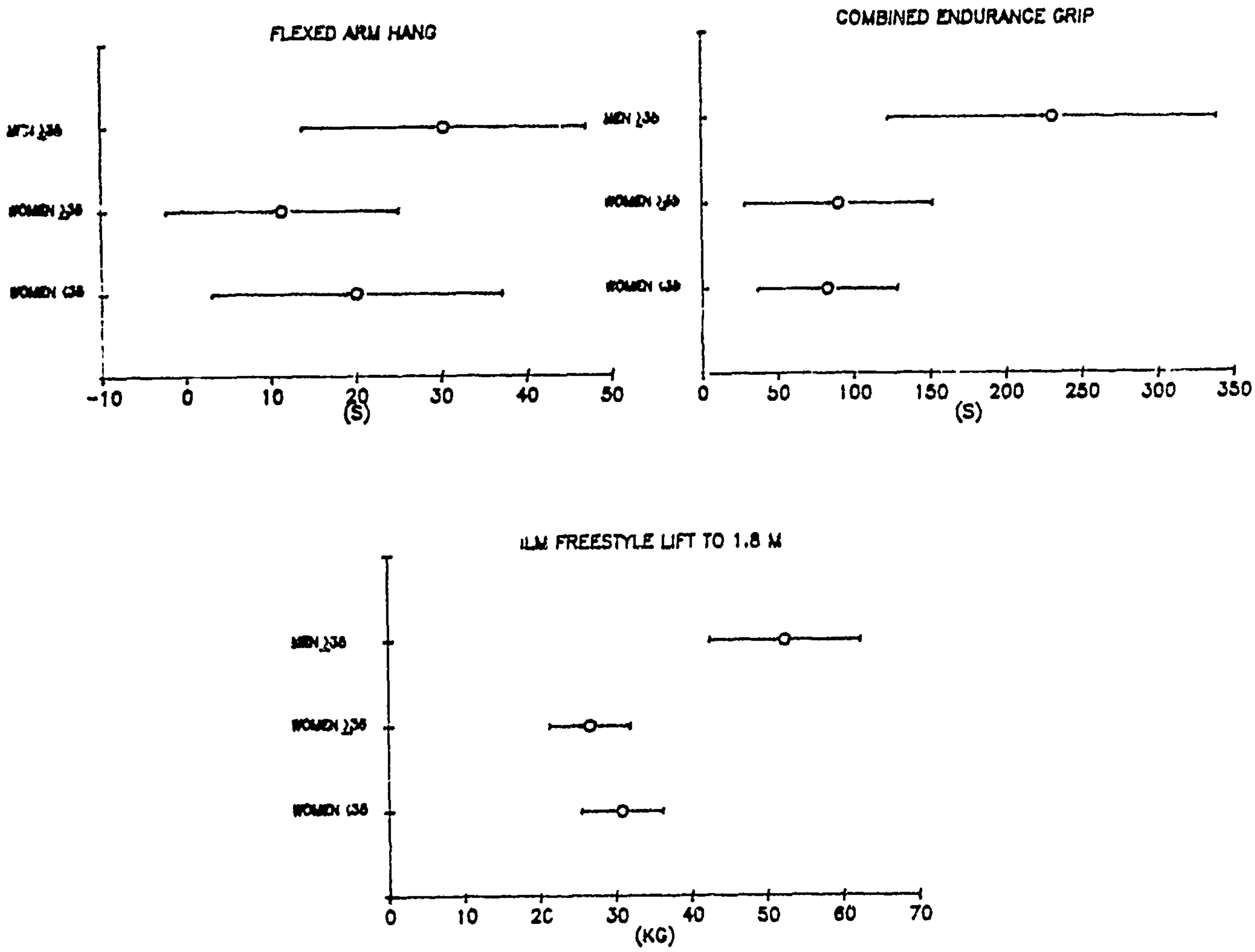

Figure A3. Graphic display of laboratory test scores of the sample by age and group. The o represents the mean scores and the bar represents one standard deviation.

Table A6 Summary of Laboratory Test Scores of the Sample by Age Group and Sex.

	Flexed Arm Hang (s)	Combined Endurance Grip (s)	ILM Freestyle Lift to 1.8m (kg)
Women < 35 years n= 59			
Mean	20.0	82.4	30.8
SD	17.1	46.2	5.4
(min-max)	(0-62)	(15-203)	(20.0-55.0)
Women ≥ 35 years n= 28			
Mean	11.3	89.8	26.6
SD	13.7	62.0	5.4
(min-max)	(0-45.8)	(25-275)	(20.0-42.5)
Men ≥ 35 years n= 62			
Mean	30.4	231.2	52.4
SD	16.7	108.6	10.0
(min-max)	(2.2-76.1)	(59-547)	(35.0-80.0)

protocol lowered the ILM scores. In Phase III, the less restrictive freestyle protocol allowed subjects to improve their ILM score; this occurred despite the fact that the structure of the ILM required a unique manoeuver not found in actual lifting tasks. The ILM freestyle lift has been performed on 149 subjects in this study, and no incidents of injury resulted. This would indicate that the ILM test protocol was safe for all subjects.

A4.4 Summary of Field Tasks

Table 7 presents the summary of field tasks by sex, group and age levels. In performance of the tasks, older men completed them more quickly than younger women, despite being restrained with heart rate monitors. Similar significant differences were found between younger and older women, probably due to the heart rate restriction. However, individuals differed widely as suggested by the standard deviations in the data. A graphic presentation of the tasks is provided in Figure 4a-e. The graphs contain data for men <35 years for comparative purposes. In addition, the graphs have pass/fail lines representing the proposed time for older and younger groups. The men performed better on the average than women in the same age group, however the range of scores was greater for women. Older men also performed tasks on the average faster than younger women despite the safety restriction. This in part is due to the nature of the tasks selected in that they were physically demanding tasks and partly due to male-dominant task definitions (carry an 80 kg person or lift 20 kg sandbags). As male strength has been reported to be 35%-70% greater than female strength depending on task definition sample studied or predictive tests used, it is not surprising that this study would demonstrate this magnitude of disparity by gender.

Comparing Phase II with Phase III data for younger women, differences in the entrenchment dig, sea evacuation, low high crawl and sand bag tasks were small (12.6 s, 12.5 s, -5.3 s and +1 s respectively). The land evacuation

Table A7 Summary of field tasks by sex and age level.

	Land Evacuation Total time (s)	Low-high Crawl Total time (s)	Entrenchment Dig Total time (s)	Sea Evacuation Total time (s)	Sandbag Carry Total # bags carried
Women < 35					
Mean	771.6	144.1	498.2	148.0	12.2
SD	226.4	43.0	135.7	158.3	2.0
(min-max)	(445-1656)	(64.6-295.3)	(256-953)	(27-747)	(7-18)
Women ≥ 35					
Mean	960.3	212.0	630.5	259.5	9.5
SD	297.6	66.6	180.4	244.1	1.4
(min-max)	(470.5-1607)	(86.1-355.8)	(373-1081)	(36-912)	(8-12)
Men ≥ 35					
Mean	582.9	122.2	408.9	40.1	12.1
SD	167.5	56.8	136.6	15.1	2.6
(min-max)	(288-1084)	(58.7-330.7)	(216-809)	(21-97)	(8-19)

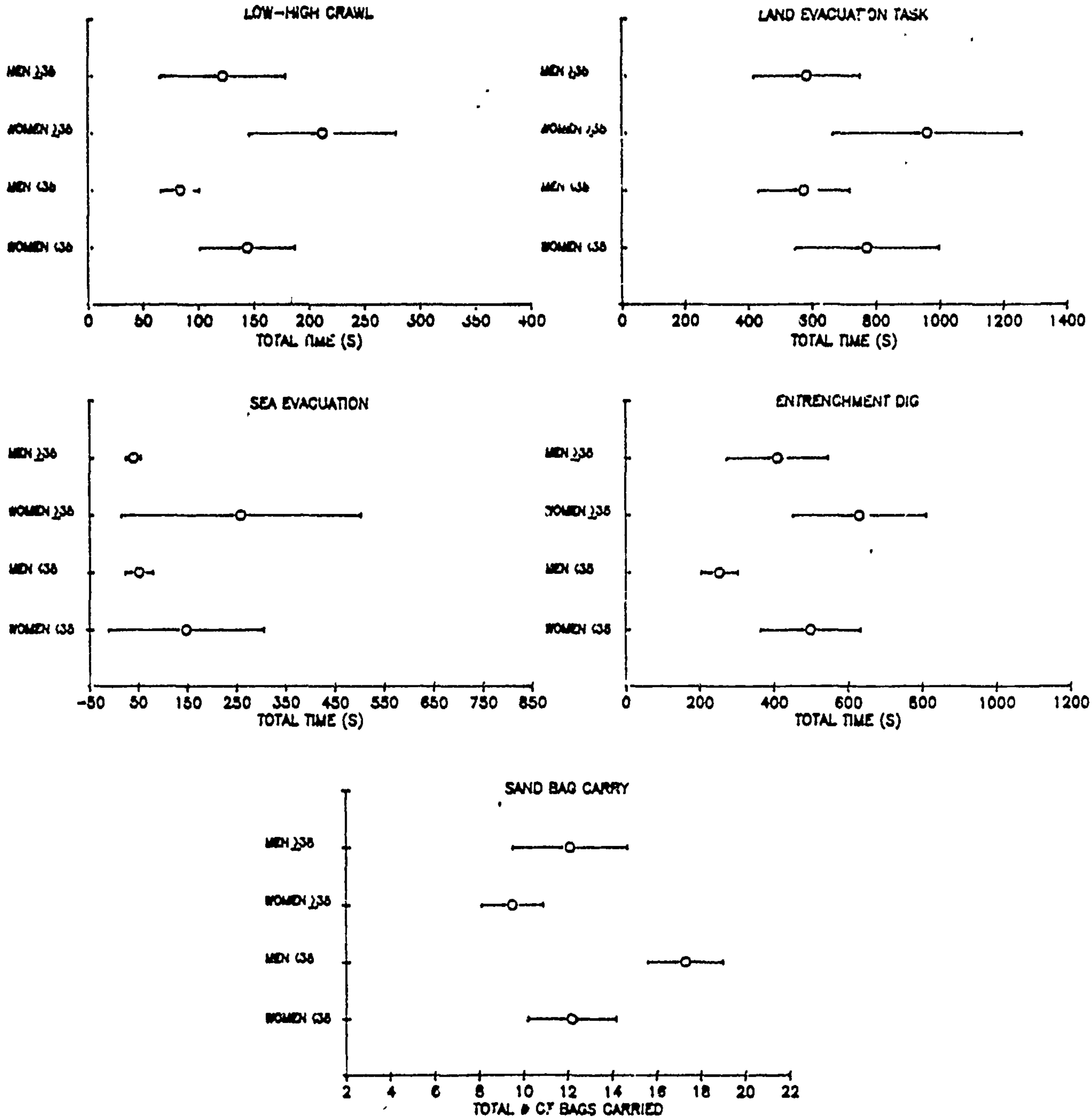

Figure A4. Graphic display of field task scores of the sample by age and group. Data for men <35 years from Phase II has been included to present a clearer understanding of all groups. The o represents the mean scores and the bar represents one standard deviation.

task could not be compared as the course length had been changed from 1 km to 750 m. Older women required slightly longer (1.5-2.5 min) on tasks than the small group of elite women in Phase II. The older men in Phase III were faster in low high crawl, entrenchment dig and sea evacuation than men from Phase II (9.0 s, 50.8 s, 34.8 s respectively). This was probably a result of a more fit sample than in the previous year, as determined by EXPRES.

A5 INFERENTIAL RESULTS

A5.1 Introduction

In previous contracts it has been shown that one could not reliably predict task performance from general fitness measurements. However, some of the variance in task scores was attributable to fitness scores, thus indicating with reasonable assurance that general fitness did relate to task performance. Hence, a minimum physical fitness standard for CF personnel was warranted.

A similar analytical approach to previous years was taken with this sample population; however, because of the predominance of older men and women in Phase III (in contrast with the younger subjects in Phase II), it was possible to address the important question of age restriction and its effect on older subjects. Figure A1 (shown in the Methods section under A3.5) is a depiction of the procedures which were followed and explained earlier in this report. Each step will be explained in greater detail below and comparisons to previous years data will be identified more substantially in Part B.

A5.2 Simple Correlation

Simple correlations between performance measures and selected fitness components are shown in Tables A8a - 8c. The Tables are divided into anthropometric measures, muscular strength and endurance measures, and aerobic capacity. Those variables which had a significant probability ($p<.001$) of being correlated to fitness test variables are plotted in Figures A5a-c.

In Table A8a for women <35 years, no single test variable accounted for more than 38% of the variance in task scores (entrenchment dig $r=.62$; $r^2=38\%$). When EXPRES variables only were considered, less than 26% of the variance in task score data could be explained. This was similar to results found in Phase II. The correlation between performance measures and fitness components

Table A8a Correlations (r) Between Performance Measures and Selected Fitness Components for Women less than 35 years.

Fitness Parameters	Land Evacuation	Low High Crawl	Entrenchment Dig	Sea Evacuation	Sandbag Carry
Anthropometry					
Age	.37	.32	.08	.18	-.24
Height	-.38	.08	-.33	-.32	.15
Weight	-.08	.31	-.22	.09	-.05
Muscular Strength and Endurance					
Situp	-.45*	-.41	-.28	-.20	.42
Pushup	-.37	-.47*	-.35	-.21	.44
Combined Grip	-.38	-.22	-.43	-.13	.39
Endurance Grip	-.32	-.27	-.50*	-.25	.24
Flexed Arm Hang	-.45	-.59*	-.43	-.42	.53*
Maximum ILM to Full Extension	-.52*	-.46*	-.62*	-.27	.50*
Aerobic Capacity					
Step test	-.40	-.51*	-.16	.38	.42

Note * p<.001.

Table A8b Correlations (r) Between Performance Measures and Selected Fitness Components for Women 35 years or older.

Fitness Parameters	Land Evacuation	Low High Crawl	Entrenchment Dig	Sea Evacuation	Sandbag Carry
Anthropometry					
Age	-.25	-.06	-.04	-.05	.05
Height	-.49	-.09	-.42	-.65	.32
Weight	-.06	.46	-.19	.10	.06
Muscular Strength and Endurance					
Situp	-.32	-.37	-.11	-.31	.21
Pushup	-.10	-.10	-.19	-.08	.08
Combined Grip	-.64*	-.34	-.46	-.63	.42
Endurance Grip	-.64*	-.49	-.43	-.56	.48
Flexed Arm Hang	-.49	-.64*	-.11	-.53	.20
Maximum ILM to Full Extension	-.34	-.20	-.23	-.27	.20
Aerobic Capacity					
Step test	-.33	-.56	-.40	-.32	.56

Note * $p<.001$.

Table A8c Correlations (r) Between Performance Measures and Selected Fitness Components for Men 35 years or older.

Fitness Parameters	Land Evacuation	Low High Crawl	Entrenchment Dig	Sea Evacuation	Sandbag Carry
<u>Anthropometry</u>					
Age	.30	.30	.21	.24	-.34
Height	-.21	-.07	-.09	.03	.27
Weight	-.01	.37	-.21	.16	.04
<u>Muscular Strength and Endurance</u>					
Situp	-.46*	-.52*	-.27	-.30	.48*
Pushup	-.41	-.38	-.17	-.32	.53*
Combined Grip	.01	.09	-.14	-.02	-.02
Endurance Grip	-.47*	-.21	-.25	-.40	.45*
Flexed Arm Hang	-.36	-.49*	.09	-.43	.42
Maximum ILM to Full Extension	-.34	-.18	-.31	-.25	.42
<u>Aerobic Capacity</u>					
Step test	-.52*	-.46*	-.27	-.32	.62*

Note * $p<.001$.

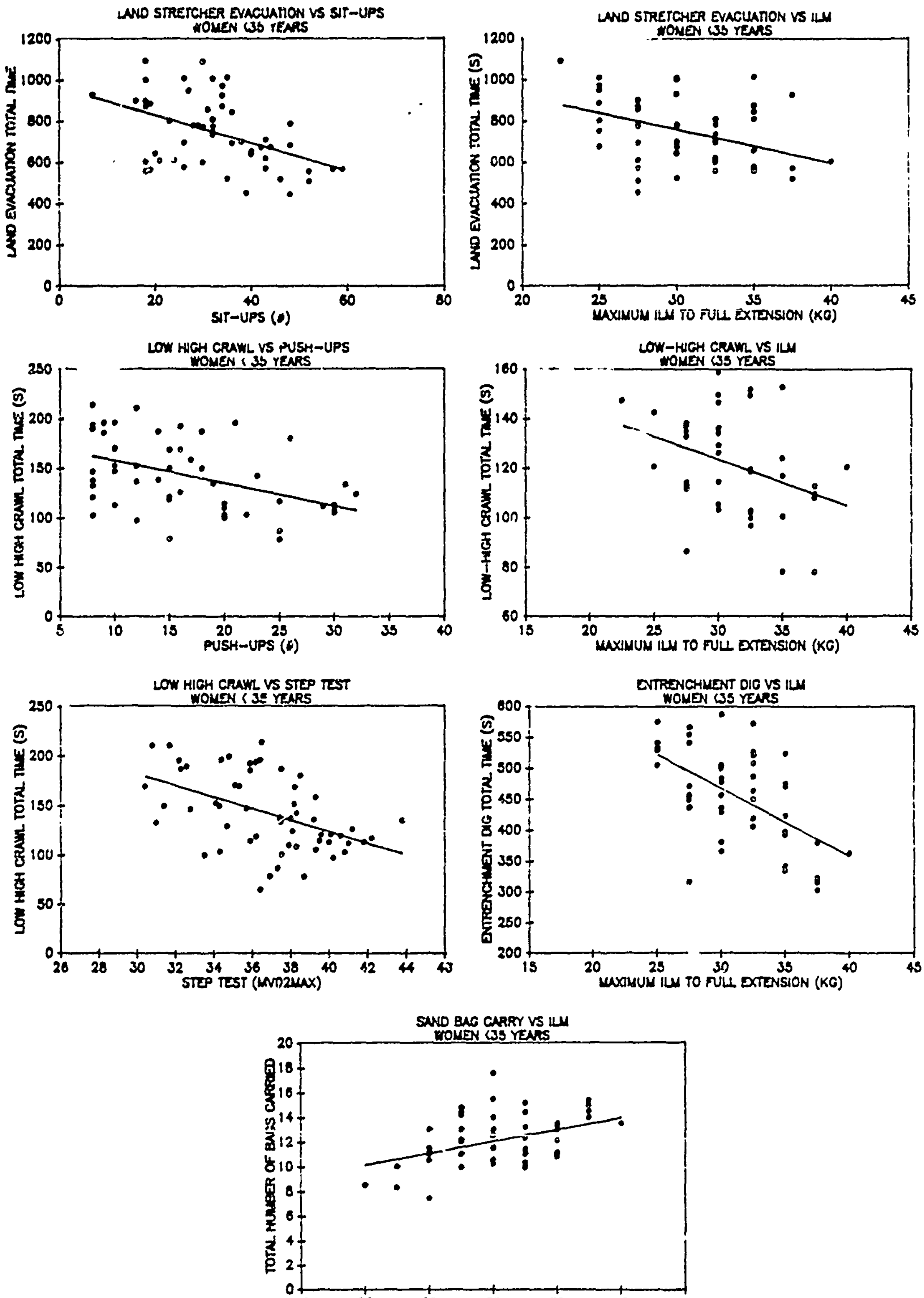

Figure A5a. Graphic display of those fitness measures which had a high probability (p<.001) of being correlated to task performance for Women less than 35 years.

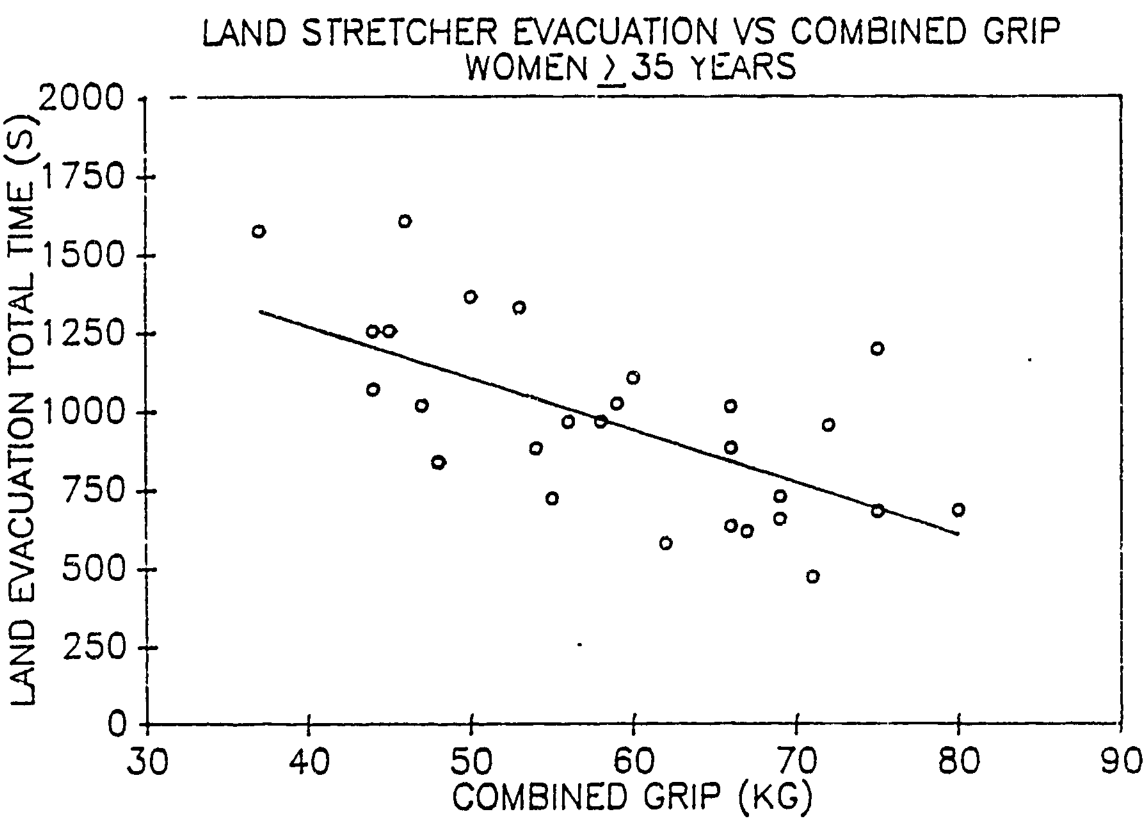

Figure A5b. Graphic display of those fitness measures which had a high probability ($p<.001$) of being correlated to task performance for Women 35 years or older.

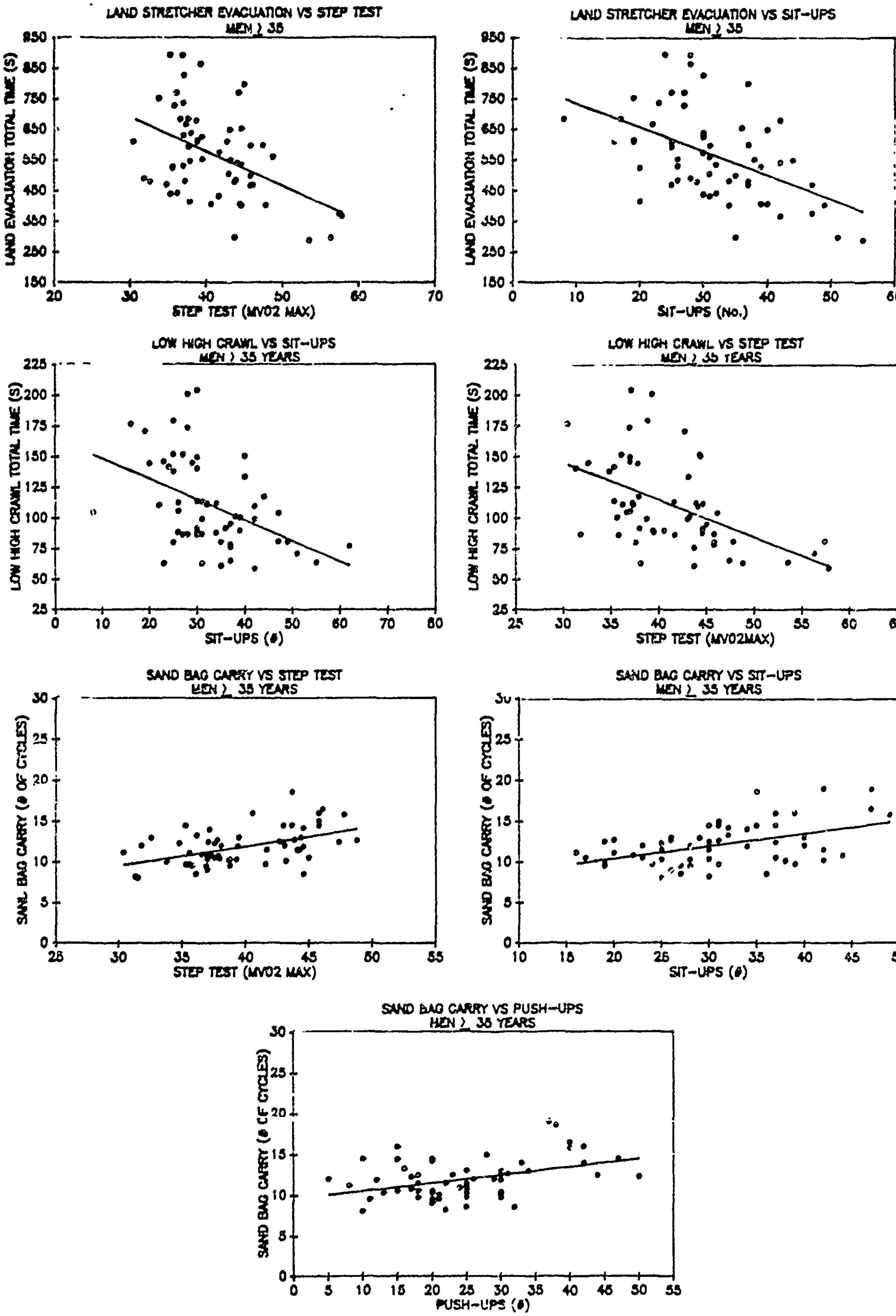

Figure A5c. Graphic display of those fitness measures which had a high probability ($p<.001$) of being correlated to task performance for Men 35 years or older.

for older women is shown in Table A8b. Again, no variable could account for more than 40% of the variance in performance scores. Similar observations were made for the older male population in Table A8c, where not more than 27% of the variance in performance scores could be accounted for by EXPRES fitness variables. The Figures A5a-c highlight the variability of performance. This variability is not unexpected as fitness measures are only one component of task performance. As with Phase II the variables which related to performance differed between the three groups.

A5.3 Multiple Linear Regressions

While simple correlation indicated a high probability of a relationship among certain fitness parameters and task performances, correlations were poor. Thus, in order to test the possibility that several parameters interacted in a way to produce a highly correlated predictive model for task performance, multiple correlations using regression analysis were determined; the pass test for a variable to be included in the regression model was $p<.05$.

A summary of the results of the multiple linear regression models are shown in Tables A9a - A9c. An examination of the regression coefficients for the produced equations showed little improvement over the simple correlation case. For younger women, multiple linear regression equations could explain from 18% to 50% of the variance in task performance scores. The regression equations included almost an equal number of EXPRES and additional laboratory tests in the equations. The variables for the younger women's group differed from the variables within the equations for older women and older men. Muscular strength or endurance variables were identified for the entrenchment dig and sea evacuation, whereas strength and aerobic variables were indicative of performance in the land evacuation, low-high crawl and sandbag carry.

In Table A9b, for older women, fitness variables explained 22% - 64% of the variance in task performance. Although small differences existed, older

Table A9a Stepwise Regression for Tasks using all fitness parameters with women less than 35 years.

Task/Variables in Equation	B	SE B	Mult R	R^2	F	P
Entrenchment Dig						
Constant	1061.70	111.45				
ILM	-11.92	2.63	.57	.32	24.72	.001
Max Grip	-2.77	1.29	.61	.38	15.51	.001
Land Evacuation						
Constant	1886.36	235.89				
Situps	-5.74	1.83	.49	.24	16.54	.001
ILM	-12.14	4.02	.58	.34	13.25	.001
VO_2 Max	-15.59	5.62	.66	.43	12.55	.001
Low High Crawl						
Constant	392.03	55.66				
Flexed Arm Hang	-.91	.30	.58	.34	26.56	.001
VO_2 Max	-4.00	1.31	.64	.41	17.91	.001
ILM	-2.66	.89	.71	.50	16.80	.001
Sea Evacuation						
Constant	233.70	31.39				
Flexed Arm Hang	-4.07	1.21	.42	.18	11.34	.001
Sandbag Carry						
Constant	2.21	2.81				
Flexed Arm Hang	.03	.02	.48	.23	15.87	.001
ILM	.13	.04	.57	.32	12.07	.001
VO_2 Max	.15	.07	.62	.38	10.32	.001

Table A9b Stepwise Regression for tasks using all fitness parameters with women 35 years and older.

Task/Variables in Equation	B	SE B	Mult R	R^2	F	P
Entrenchment Dig						
Constant	750.27	.54				
Endurance Grip	-1.32	63.15	.47	.22	6.03	.05
Land Evacuation						
Constant	2923.68	451.39				
Max Grip	-16.55	3.82	.66	.44	16.42	.001
VO_2 Max	-24.81	11.98	.75	.57	13.22	.001
Low High Crawl						
Constant	500.97	93.16				
Flexed Arm Hang	-2.82	.79	.63	.40	13.76	.001
VO_2 Max	-8.48	2.91	.73	.53	11.31	.001
Pushups	2.70	1.51	.80	.64	11.08	.001
Sea Evacuation						
Constant	1092.20	224.83				
Max Grip	-13.71	3.64	.63	.40	14.17	.001
Sandbag Carry						
Constant	.28	2.14				
VO_2 Max	.24	.06	.57	.32	9.99	.01
Endurance Grip	.02	.004	.72	.52	10.81	.001
Flexed Arm Hang	-.05	.02	.78	.61	9.89	.001

Table A9c Stepwise Regression for tasks using all fitness parameters with men 35 years and older.

Task/Variables in Equation	B	SE B	Mult R	R^2	F	P
Entrenchment Dig						
Constant	615.72	92.39				
ILM	-3.96	1.74	.29	.08	5.19	.05
Land Evacuation						
Constant	1124.10	122.06				
VO_2 Max	-10.71	2.96	.46	.21	14.72	.001
Endurance Grip	-.48	.17	.56	.31	12.26	.001
Low High Crawl						
Constant	233.86	22.77				
Situps	-2.60	.82	.54	.29	23.0	.001
Flexed Arm Hang	-.93	.43	.59	.35	14.65	.001
Sea Evacuation						
Constant	58.07	4.60				
Flexed Arm Hang	-.31	.09	.41	.17	11.22	.001
Endurance Grip	-.04	.02	.51	.26	9.85	.001
Sand Bag Carry						
Constant	-2.18	1.97				
VO_2 Max	.23	.04	.61	.36	32.50	.001
ILM	.07	.03	.71	.50	27.48	.001
Endurance Grip	.01	.002	.74	.54	21.20	.001

women had many of the same variables in the regression equation as younger women. It is noted that both the entrenchment dig and sea evacuation contained variables of muscle strength and endurance only, whereas the remaining three tasks consisted of both aerobic and strength variables.

In Table A9c are the linear regression equations for older men, where 8%-54% of the task variance could be explained by fitness parameters. Unlike the women's data, the land evacuation and the sandbag carry contained both aerobic and strength variables, whereas the entrenchment dig, low-high crawl and sea evacuation consisted only of strength variables. This was consistent with observations of task performance where men and women performed the tasks differently. It would therefore be logical to assume that different parameters would be related to task performance between genders.

A5.4 Determination of Passing Criteria

In Phase II, a common task criteria was determined based on the point at which 75% of the pooled sample of young men and women passed the task. In this study, no younger men were tested so the women <35 years were subjected to the same 75th percentile time for passing each task as determined in Phase II. This cut off did not appear inappropriate as the task times for women were comparable between the two samples. In Phase II older men were assessed using the 90% heart rate restriction with results matching the combined scores of men and women <35 years very closely. However, no data were collected to examine the impact of restricted performance nor were any data collected with older women. As a result, a passing criteria was required for older subjects which would reflect the extent to which the 90% safety restriction altered task performance scores, and to create a standard which was based on the performance results of older men and women.

A small sub-study was undertaken on subjects ≥35 years to compare restricted versus unrestricted protocols. Volunteers completed both a 90% heart rate entrenchment dig and a 100% entrenchment dig under the supervision of a physician. In addition, a maximal treadmill test was performed to determine directly the true maximal heart rate and aerobic capacity.

Table A10 presents data on 16 men and 3 women for maximal oxygen consumption and for heart rate and dig time for both the restricted and unrestricted tasks. In the case of the restricted task, 90% heart rate maxima were established using the formula 90% HR =.9([220-age]-70)+70 bpm. The mean VO_2 max for men was 40.88 ml/kg/min with an average maximum heart rate of 185.8 beats/minute. The 90% heart rate calculated by means of an age adjusted maximum was 161.54 beats/minute for men whereas the true 90% heart rate as calculated from true maximals was 166.25 beats/minute. Some calculations were over- or under- estimated by as many as 20 beats/minute. Although maximal heart rate in general was related to age, the forced restriction affected some subjects.

The unrestricted dig times were improved by 110.25 seconds with nine males achieving scores which were either within a minute or less than their previous score (x=-.67s); the remaining nine subjects improved their scores (x=213.8 s). In other words, when the heart rate restriction was removed, entrenchment dig scores on average were improved 36.2% for the men and 32.3% for the women. Closer examination of individual results clearly indicates that performance scores of those with true maximal heart rates higher than predicted were adversely affected (i.e., performance underestimated); the opposite applies to those with lower maximal heart rate. In short, not all older subjects were affected equally.

As the safety restriction created a different protocol for older subjects, it was necessary to determine a passing criteria based on a sample of well distributed equal numbers of older men and women. As there were

Table A10 Raw data and summary statistics for subjects who performed the entrenchment dig under restricted and unrestricted conditions.

			Unrestricted Performance		Restricted Performance	
Subject I.D.	Age In Years	*Maximal Oxygen Consumption ml/kg/min	True 100% Heart Rate beats/min	Entrenchment Dig (100%) seconds	Predicted 90% Heart Rate beats/min	Entrenchment Dig (90%) seconds
Males						
1409	35	47.4	200	306	174	566
1503	35	48.8	208	227	174	464
1602	36	45.8	189	286	173	445
1301	38	31.8	190	239	171	216
1604	38	45.0	209	360	171	646
1702	38	44.3	183	511	171	470
1804	38	44.6	186	362	171	316
1603	40	32.6	189	218	169	301
1703	40	39.5	165	369	169	300
1701	41	37.0	176	317	168	375
1302	44	36.2	173	318	165	260
1401	44	28.8	176	334	165	604
1403	45	36.6	189	266	165	501
1404	45	45.8	181	245	165	637
1803	49	37.2	175	269	161	273
1801	49	40.6	179	234	161	248
Mean		40.88	185.81	303.62	161.54	413.88
S.D.		5.28	11.70	72.28	29.73	142.34
Females						
1709	39	33.3	197	448.9	170	490
1509	40	39.8	185	325.0	169	483
1305	40	36.3	184	487.7	169	680
Mean		36.47	188.67	420.53	169.33	551
S.D.		2.66	5.91	69.36	0.47	91.26

* A maximal oxygen consumption test was used to determine true maximal heart rate.

unequal sample sizes, three randomized subsamples of 28 males were selected, and averaged to combine with the total sample of 28 females. Cumulative frequency histograms were created and the 75th percentile task performance scores were determined. Interesting to note is that the average difference in task requirements were 32% longer than for younger subjects. As these results were comparable to the restricted versus unrestricted substudy using the entrenchment dig, it was assumed that all other tasks likewise were restricted by the heart rate monitor, as evidenced by the number of times older subjects were required to stop and wait until the heart rate monitors returned into the target zone. This adjustment seemed a reasonable criterion to compensate older subjects for the safety restraint. The younger subjects task performance criteria and older subjects task times are presented in Table A11.

A5.5 Description of Passing Groups

Having established reasonable passing criteria for the task performances, all subjects were identified as having passed or failed individual tasks. For the passers, a profile of EXPRES and additional laboratory tests were established for each task. This provided a mean and standard deviation for each of the EXPRES variables for the passing group. Using this description as a basis, z-scores for normal distributions were used to predict the 5th percentile of the passing group. That is, of the fitness scores obtained by the passing group, the lowest 5% of these scores were taken to be the minimum required to perform the task. By inference, this creates a 5% likelihood of falsely classifying a passing person as a failing one. For each of the tasks, the EXPRES scores for the 5th percentile of the passing groups were tabulated (Table A12a-e). Using Table A12a as an example the 5th percentile score for personnel passing the entrenchment dig are shown. For women <35 years, a maximal grip score of 58.8 kg represented the 5th percentile of the passing group. This variable appeared in the regression equation and was evident in

Table A11 Criterion used as pass/fail times for each of the task performances.

Task Criteria	Men and Women < 35 years	Men and Women ≥ 35 years
Entrenchment Dig (s)	510	673*
Land Evacuation (s)	900**	1188
Low High Crawl (s)	140	185
Sea Evacuation (s)	210	277
Sandbag Carry (# of bags)	12***	9

* The 32% reduction in passing criteria was based on a substudy of men and women comparing restricted and maximal dig performance which revealed a 32% reduction in performance with the 90% heart rate restriction criteria.

** There were no data available for younger men on 750 m Land Evacuation tasks. The passing time was calculated as 3/4 of the total time for 1 km from Phase II.

*** The number of sandbags to be carried by younger subjects was determined on the basis of a matched sample size of men and women <35 from Phase II.

Table A12a Fifth percentile scores for personnel passing Entrenchment Dig by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	58.8[bd]	42.2[a]	73.0
VO_2 Max	31.1	29.1[a]	31.1[a]
Situps	12.9	10.1	15.2
Pushups	-2.5	-5.8[a]	5.0
Queen's			
ILM	24.0[abcd]	16.9[a]	35.8[d]
Endurance Grip	19.2[abc]	-13.7[d]	59.5[a]
Flexed Arm Hang	-5.5[ab]	-10.0[a]	2.9[a]

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis.

Table A12b Fifth percentile scores for personnel passing Land Evacuation by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	57.7	17.9[bcd]	72.9
VO_2 Max	31.2[ad]	28.1[d]	31.2[abcd]
Situps	15.2[abcd]	9.9	15.4[ac]
Pushups	-2.11	-2.26	5.1
Queen's			
ILM	22.9[abcd]	18.3[ab]	35.9
Endurance Grip	15.8	9.8[abc]	58.3[acd]
Flexed Arm Hang	-6.9[b]	-7.8[b]	2.8

Note a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

Table A12c Fifth percentile scores for personnel passing Low-High Crawl by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	65.3	43.2	72.7
VO_2 Max	33.1[abcd]	29.7[abd]	31.1[c]
Situps	15.4[b]	11.8[b]	16.8[abcd]
Pushups	0.75[abc]	-3.0[ad]	5.5
Queen's			
ILM	23.1[abcd]	17.6[a]	36.1
Endurance Grip	10.3	-2.9[b]	54.6
Flexed Arm Hang	1.2[abcd]	-9.15[abcd]	4.4[cd]

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

Table A12d Fifth percentile scores for personnel passing Sea Evacuation by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
<u>EXPRES</u>			
Maximum Grip	56.3	49.5[bd]	73.5
VO_2 Max	31.2	28.0	30.7
Situps	13.3	9.9	15.6
Pushups	-1.3	-2.5	7.0
<u>Queen's</u>			
ILM	23.5[ab]	17.6	36.6
Endurance Grip	13.3	13.5[ab]	59.4[d]
Flexed Arm Hang	-4.0[abd]	-7.1[a]	2.8[d]

<u>Note</u>. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

Table A12e Fifth percentile scores for personnel passing Sandbag Carry by sex and age level.

Variables	Women $<$ 35	Women $\geq$ 35	Men $\geq$ 35
EXPRES			
Maximum Grip	57.0	41.5[a]	72.7
VO_2 Max	32.0[abd]	29.1[ad]	31.3[acd]
Situps	15.1[b]	7.4[a]	15.3[c]
Pushups	0.42[b]	-5.7[a]	7.1[c]
Queen's			
ILM	23.0[abcd]	19.1	36.4[d]
Endurance Grip	13.8	-10.4[ad]	72.3[abcd]
Flexed Arm Hang	0.02[abcd]	-11.3[ad]	3.6

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

the mean differences between passing and failing groups. The other characteristics which depicted this passing population of younger women were an oxygen consumption of 31.1 kg/ml/min, 12.9 sit-ups, and -2.5 push-ups. As the original push-up data were unrealistically low, the z-scores would create a negative push-up requirement; this, of course, is not logical. The requirements for older women who passed the entrenchment dig were lower scores for all EXPRES variables, especially the grip strength. For older men, the grip requirement was 24.2 kg to 30.8 kg more than younger or older women respectively, whereas the oxygen consumption value was relatively low for men at 31.1 kg/ml/min, in comparison to their female counterparts. Sit-ups, however, were higher for older men than for both younger and older women.

It was obvious from Tables A12a-e that significant relationships in fitness variables differ between groups. For example in Table A12b, the land evacuation task, a relationship existed between oxygen consumption and sit-ups for younger women, whereas the relationship was between maximum grip strength and oxygen consumption for older women. For men, the relationships were oxygen consumption and sit-ups. It was interesting to note that grip strength required for younger women was far greater than that for older women. This trend continued through all of the tasks and was attributed to a skewed sample of grip scores by younger women. The variables of oxygen consumption and sit-up scores followed a logical drop-off, as would be expected with age. For older men, the grip values were much higher than for women; however, oxygen consumption requirements were very close to that of younger women but larger than that for older women. The sit-ups for older men were often two or three more than required for younger women but often as many as six more than older women. The number of push-ups for the men varied from five to seven, as the 5th percentile of the passing group; however, the push-up data for women was not acceptable as there was doubt to the authenticity of the data.

It was interesting to note that from the Queen's station, the ILM test was more closely related to task performances for women than for men. This was particularly true of younger women, where there was a relationship between ILM and every task. The flexed-arm hang also tended to show a close relationship to performance variables.

In summary Tables A12a-e the 5th percentile of the passing group for each task were identified . In addition, variables which were related to EXPRES and laborato tests were identified. Results revealed that the underlying fitness varia 'es which related to task performance differed for each group. Second, each group had different fitness scores to represent the 5th percentile of the passing group. Lastly, poor performance by women's push-up, endurance grip and flexed arm hang created erroneous 5th percentile values and thus cannot be used for creation of standards.

5.6 Development of a Physical Fitness Standard

Table A13 is a summary of the reliable relationships between EXPRES items and the ILM and the five task variables. As with Phase II, the relationships differed between groups, as could be expected because of different techniques, especially between men and women. Table A13 was used as the basis to develop a minimum physical fitness standard (MPFS) for each of the identified fitness parameters individually. As in previous years, the value which was chosen as a minimum was selected on the basis of being related to the task as indicated in Table A13 and by being the highest of the passing requirements. For example, oxygen consumption for younger women was related to the land evacuation task, low-high crawl and sandbag carry, with oxygen consumption requirements of 31.2, 33.1, and 32.0 ml/kg/min, respectively (Tables A12b,c,e). As the low-high crawl required the highest oxygen consumption value (33 ml/kg/min), this was the recommended physical fitness standard for

Table A13 Summary of reliable relationships between EXPRES items and task variables using simple correlation, regression and discriminant analysis.

EXPRES	Entrenchment Dig	Land Evacuation	Low High Crawl	Sea Evacuation	Sandbag Carry
Women < 35 years					
Grip	bd				
VO_2 Max		ad	abcd		abd
Situps		abcd	b		b
Pushups			abc		b
ILM	abcd	abcd	abcd	ab	abcd
Women ≥ 35 years					
Grip	a	bcd		bd	a
VO_2 Max	a	d	abd		ad
Situps			b		a
Pushups	a		ad		a
ILM	a	ab	a		
Men ≥ 35 years					
Grip					
VO_2 Max	a	abcd	c		acd
Situps		ac	abcd		c
Pushups					c
ILM					d

Note a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

that EXPRES variable. This process was continued for all EXPRES parameters and the ILM test. The results of this process are presented in combination with previous data in Table A14.

Comparing results for Phase III and Phase II, for the younger women it could be seen that there was a great disparity in minimum grip requirement (Table A14). This was attributed to a skewed sample in Phase III in that 78% of the women tested under thirty-five years of age had a combined grip score of excellent or good (Table A4), in comparison to 32.2% in the same categories in Phase II. The oxygen consumption requirement was somewhat higher than Phase II data, presumably a result of a more fit sample in this phase. Unfortunately, the push-up minimum fitness standard was not valid as the EXPRES scores for push-ups contained forty-two of the fifty-one subjects in the poor category. This was a result of the protocol change in push-up requirements between Phase II and Phase III. An explanation for the differences in sit-ups was not obvious and hence was probably a result of other factors affecting the variance in the data. The ILM lift could not be compared between Phase II and Phase III because the protocol differed. Phase III consisted of a free-style ILM lift to 1.8 m, whereas Phase II was a lift without stopping to 1.8 m.

For older women, since there were no data from Phase II available, a detailed description of the EXPRES characteristics were identified. In combined maximum grip, 40% of the women sampled were in the good and excellent categories. This would skew the values somewhat higher than might be expected. This was also true for oxygen consumption, in that 64% of the sample population were at the 80th percentile or above. As with younger women, the push-up values were of no consequence; however, the sit-ups were normally distributed and might, therefore, be reasonable. There were no data to compare ILM lift scores as the protocol also differed.

Table A14 Minimum Physical Fitness Standards

	Women <35		Women ≥35	Men <35*		Men ≥35	
	MPFS2	MPFS3	MPFS3	MPFS1	MPFS2	MPFS2	MPFS3
Maximum Grip (kg)	(45)	59	48	75	77	(77)	73[1]
VO_2 Max	(30)	33	30	39	40	(35)	31
Pushup (#)	(21)	1	0	19	14	(14)	7
Situp (#)	(24)	15	12	22	21	(27)	17
ILM (kg)	(17.5)	25	18.5	**	**	(35)	35

Note. [1]=Variable not identified as relevant to any task, therefore mean 5th percentile of passing groups across tasks was used.

* Note these data are from the Phase I and Phase II reports.

** Protocol changes between Phase II and Phase III. Only Phase III data is approporiate for present implimentation.

For older men the combined grip scores closely matched those of the previous year; this was not unexpected as the samples appear to be similar. The oxygen consumption value was lower than in Phase II. A similar trend was evident for push-ups and sit-ups, where the values dropped markedly from the previous year. The reduced standards were a direct result of combining men and women in order to develop a common task criteria. As men's task performance times were significantly better than women's (Table A7), the 75th percentile cut off would in effect lower the fitness requirement in Phase III. It could be argued that Phase II data were more reasonable for older men in that a restricted but safe criteria were used and that three of the four subgroups could be accommodated by this model. This would create a situation where special criteria would be required for older women. For the ILM test with a different protocol, the lifting requirements would appear the same at 35 kg.

A6 IMPLICATIONS

A6.1 Introduction

As with Phase II, no common standard could be used to describe the fitness of those subjects able to pass performance standards for the tasks without taking into account gender and age. As a result, three sets of standards were proposed and outlined in Table A14.

The justification for separate standards can be made in several ways:

1. Biomechanically, it was observed that the tasks were performed differently between groups;
2. Older subjects were restrained to performance at 90% of their maximal capacity based on a common heart rate corrected by age;
3. The strength difference on maximal grip scores was closely related to body size and thus the differences in grip scores between men and women were more marked than for sit-ups and push-ups; and
4. The fitness variables underlying task performance differed between the three groups, particularly between men and women.

A6.2 Prediction of Passing and Failing

The standards were developed task by task with no consideration given for the ability of an individual to pass all tasks. To examine this likelihood the performance criteria established for each group were used to divide the populations into passing and failing groups based on fitness scores. Next, the efficacy of this prediction was tested by counting those of the predicted passing group who were actually able to pass all task criteria. By inference, the number of false negatives was controlled at 5%, in that the minimum fitness standard was the point at which 95% of the passing group attained the fitness score. This method meant that the number of false positives was not controlled. In other words, subjects may have failed the task criteria but passed the fitness scores.

The results of cross-tabulation of predicted vs actual performance are shown in Table A15. For younger women, of those subjects who were predicted to pass all tasks, based on fitness scores, 34% were able to do so. Of those subjects who were predicted to fail the task, based on fitness scores, 22% were classified correctly. In the controlled variable, of false negatives, the incidence of subjects who were predicted to fail tasks but actually passed all tasks was 2% of the total younger women sample. In other words, the chance of error was 2% that a woman who was classified incorrectly as a person who would fail the tasks. Hopefully these subjects would be given a second chance to perform the task before sanctions by the Canadian Forces. However, the number of subjects who were false positives, or classified as being able to pass the task based on higher EXPRES scores, was 42% of the sample. This large value was a result of the poor predictive power of general EXPRES fitness variables in relationship to task performance.

For older women, a total of 68.2% were correctly classified, based on their EXPRES fitness scores. In this sample, no subjects would have been failed on false classification by EXPRES; however, 31.8% of older women who failed one or more of the tasks would have passed their EXPRES fitness test.

For older men, 74.6% were classified correctly by their EXPRES scores; however, of the ones incorrectly classified, 10.1% would have been classified as failers when they were actually passers in task performance and 15.3% would have been classified as passers when they actually failed the task performance.

When the subject groups were pooled, 66.4% were correctly classified as passers or failers of task performance, based on EXPRES fitness scores. The incidence of subjects who failed EXPRES but actually passed all tasks was 5.4% of the total sample. However, once again, hidden within the data was the

Table A15 Impact of Minimum Physical Fitness Standards on correct or incorrect classification by number of fitness standards attained by number of task requirements attained.

Fitness Test Performance	Task Performance			
	Correctly Classified*		Incorrectly Classified**	
	Subjects	%	Subjects	%
Women < 35 years				
Pass all EXPRES	17	34	21	42
Fail 1 or more	11	22	1	2
Total	18	56	22	44
Women ≥ 35 years				
Pass all EXPRES	8	36.4	7	31.8
Fail 1 or more	7	31.8	-	-
Total	15	68.2	7	31.8
Men ≥ 35 years				
Pass all EXPRES	44	74.6	9	15.3
Fail 1 or more	--	--	6	10.1
Total	44	74.6	15	25.4
Total				
Pass all EXPRES	69	52.7	37	28.2
Fail 1 or more	18	13.7	7	5.4
Total	87	66.4	44	33.6

* Pass all 5

** Fail 1 or more

large 28.2% of the population which would fail one or more of the tasks but passed their fitness test. It was not possible to control both false negatives and false positives at the same time within this analytical approach to establish standards.

A6.3 A Comparison of Proposed Standards to Military and Canadian Population

In a similar manner to Phase II of the contract, a comparison was made between the proposed standards for this sample population with normative data from military and Canadian populations. The impact of the proposed standards could then be used to identify the number of military personnel who would require remedial programs to attain the minimum fitness score (see Table A16).

For younger women, the proposed grip strength of 59 kg from this sample would require the 35th percentile for women between the ages of 20 to 29, and 40th percentile for 30 to 39 years of the military normative data. Since the military are more fit than Canadians, this would mean that the 73rd percentile for women 20 to 29 years and 70th percentile for women 30 to 39 years would be required. Since the military is attempting to define a minimum physical fitness standard, it is not logical that levels which exceed the 50th percentile of the Canadian population would be considered. In addition this minimum requirement is markedly different from Phase II data, where a combined grip requirement was a : the 5th percentile of military normative data and at the 20 to 25th percentile for Canadian normative data. This extreme difference is reflective of the skewed sample population in combined grip score in Phase III. Upon examination of the proposed standard for oxygen consumption, younger women would be required to be above the 10th to 35th percentile, depending on age. In terms of Canadian normative data, this would require aerobic capacities in the 15th to 45th percentile. These percentile requirements are 10 percentage points above the expectations from the sample population in Phase II; again, this seemingly due to a skewed sample in Phase

Table A16 Examination of the Minimum Physical Fitness Standards relative to normal.

Normative Sample	Age Range	Combined Grip	VO_2 Max	Pushups	Situps
Women < 35 years Proposed MPFS		59	33	1	15
Military Rank (%ile)	20-29	35	10	-	<5
	30-39	40	35	-	10
Canadian Rank (%ile)	20-29	73	15	-	<15
	30-39	70	45	-	25
Women ≥ 35 years Proposed MPFS		48	30	0	12
Military Rank (%ile)	30-39	5	10	-	<5
	40-49	10	40	-	20
Canadian Rank (%ile)	30-39	27	15	-	15
	40-49	35	60	-	30
Men ≥ 35 years Proposed MPFS		73	31	7	17
Military Rank (%ile)	30-39	<5	<5	<5	<5
	40-44	<5	<5	<5	10
Canadian Rank (%ile)	30-39	7	<5	12	10
	40-49	10	25	15	15

Note. Because of the change in protocol, norms for pushups for women are not available.

III. The opposite effect is true for sit-ups, where the Phase III requirement is fifteen sit-ups, in comparison to twenty-four sit-ups in Phase II, resulting in a percentile ranking from five to ten based on military normative data, and fifteen to twenty-five for Canadian normative data.

The differences between Phases are reflective of the difficulty in making standards when only 20% to 50% of the variance in task performance can be explained by fitness scores. It is therefore necessary for the military to use sound judgment in interpretation of data presented in this manner. This becomes a difficult and arguable process which must be defended by the military in cases brought before the Canadian Human Rights Act. As only a maximum of 50% of the variance can be explained on any one task by fitness scores, this would suggest that if a subject had a 50% probability of completing the task, then they should be considered at an acceptable fitness level. This concept will be explored in the next section.

With older women the proposed minimum fitness scores are based on the hypothesis that subjects were restrained on the average 32% from their maximal capacity based on a safety restriction. With this adjustment the proposed minima fall between the 5th to 20th percentile on military normative data and 15th to 60th percentile for Canadian normative data. The variable of greatest concern is maximal oxygen consumption score for subjects in the 40 to 49 age range where older military women should be asked to be at the 60th percentile of Canadians. Once again, it is important to note that any minimum requirement above the 50th percentile should be considered unacceptable as a minimum fitness level. This is particularly true of oxygen consumption, where genetic make-up has a large bearing on aerobic capacity and training can improve this score only marginally (±20%). This would create a fitness level that is unattainable by subjects, regardless of how hard they worked to improved their aerobic capacity. The problem introduced here (a genetic limit on fitness potential) introduces another possible alternative in that a composite score could be used to evaluate fitness. For example both maximum grip strength and aerobic capacity were related to performance on the land evacuation task (Table A9b). The equation to predict a task performance would consist of the following elements; Predicted Land evacuation score = $constant_1 + coefficient_1(Grip\ score) + coefficient_2(VO_2\ max)$. This process would permit an individual to compensate for a lower aerobic fitness with an improved strength variable. As this type of compensation was observed in the way tasks are performed, this would be a reasonable and logical approach to standards. This concept and method of analysis are discussed further in Section C.

For older men the proposed fitness standards are also corrected by 32% based on the average restraint of subjects during task performance. This would create minimum standards between the first 5th and 10th percentile on military data; these values are equivalent to the 5th to 45th percentile on Canadian normative data. These standards are below the criteria established in Phase II and as discussed in Section A5.6. The CF could justify using the Phase II requirements based on safety concerns and a special program created for older women. Once again, the aerobic capacity value must be observed closely so that standards are not created which are beyond fitness capability with training.

A6.4 Evaluation of the Incremental Lifting Machine

The Canadian Forces has been giving serious consideration to the Incremental Lifting Machine as part of the occupational physical selection requirements for the Canadian Forces. As a result of this knowledge, all subjects in the present study performed a free-style ILM lift to 1.8 m using a standardized protocol where the subject was permitted 10 second to execute a maximal lift to the target height. This was a unique lift type from previous protocols in that the removal of restrictions was designed to aid subjects by allowing a more individualized approach to the lifting problem. It was hoped that this strategy would allow subjects to take advantage of their unique body strength and timing to provide their maximal possible lift on this uni-dimensional task.

Table A17 is a reminder of statistical analyses in which the ILM score and task performance were compared (also in Tables A8, 12 and 14). Although the simple correlations varied from -.18 to -.63, the correlations were somewhat higher and in greater frequency than in Phase II data, where a different ILM protocol was used. This was particularly true for younger women, where the ILM was a part of all task analyses. As a result, the ILM exceeded many of the other fitness variables in statistical relationships for this sample of younger women. This, however, was not the case in the Phase II data with the altered protocol.

For the older women's group, the ILM was related equally well to other fitness variables, whereas for older men the ILM was one of the weaker test items. When the ILM test was used as one of the minimum physical fitness parameters, minimum scores of 25 kg for younger women, 18.5 kg for older women, and 35 kg for older men were recommended. Neither the protocol nor the sample populations have been repeated and, hence, the suggestion of a standard was not appropriate. However, as the ILM test was equally as strong as other fitness measures, it is suggested that ILM testing be continued, especially if the device is to be used as an occupational strength requirement. Acquisition of normative data would, therefore, appear mandatory if judgments are to be made on various occupations using this screening device. However, at this time no fitness standards are proposed without further investigation.

Table A17 Statistical summary of relationships between ILM scores and task performance for each group.

Groups/ Statistics	Land Evacuation	Low High Crawl	Entrenchment Dig	Sea Evacuation	Sandbag Carry
Women < 35 years					
Simple correlation (r)	-.52*	-.46*	-.62*	-.27	
In regression equation	*	*	*		*
In discriminant analysis	*	*	*	*	*
Women ≥ 35 years					
Simple correlation (r)	-.34	-.20	-.23	-.63*	
In regression equation					
In discriminant analysis	*	*	*		
Men ≥ 35 years					
Simple correlation (r)	-.34	-.18	-.31	-.25	
In regression equation	*				*
In discriminant analysis					

* represents a significant relationship ($p < .05$) between the ILM and the task, either by being in the regression equation or a discriminator of passing and failing groups.

A7 DISCUSSION

A7.1 Review of Problem

Over the past three years, research projects have been undertaken to find a model which will be fair and reliable and has a measure of content validity to emergency tasks. The model that has been developed was based on a representative sample of CF personnel from four groups, men and women under 35 years and men and women over 35 years. The subject selection process was an attempt to test an evenly distributed cross-section from various fitness levels; this process was repeated on a second sample as a measure of reliability of the standards. In all tasks the criterion measure was time of task completion (except sandbag task where the criterion was number of bags carried). This model was based on using an equal representation of men and women to determine the pass/fail criteria for task performance. In order to comply with the Charter of Human Rights, a common pass/fail criteria was established for all groups set at the 75th percentile of the sample population. This percentile was designated based on an arbitrary judgment for logical task completion scores. The EXPRES and additional fitness variables were compared to task performance by means of simple correlation, step-wise regression, discriminant analysis and differences between passing and failing groups. Results of these analyses identified that the variables relating to task performance differed among groups as did the level of fitness required on the part of each passing group.

The tasks which were selected from the list of seven common tasks were deemed to be the most physically demanding and, hence, muscular strength and endurance requirements were consistently higher for women than men. This result was not unexpected; however, one major concern of the CF with this model was the reduced expectations of male performance. The problems associated with the establishment of CF minimum physical fitness standards should be identified so that this and other models can be appraised appropriately. Although this is by no means an exhaustive review of difficulties it may serve to assist in the evaluation and determination of future directions in creation of fitness standards.

A7.2 Determination of Common Tasks

The common emergency tasks and criterion measures given to Queen's University for assessment were already defined by the Canadian Forces. Although not all tasks were assessed with empirical data, there were logical assumptions on certain tasks in terms of physiological demand. However, it is important to note that nuclear biochemical warfare (N.B.C.W.) clothing increases physiological demands in terms of the task difficulty, task duration, and type of clothing worn. Unfortunately, no studies were conducted within this contract to determine the extent of increase in demand; however, it might be possible to use related literature to determine an appropriate multiplier for N.B.C.W. clothing. Regardless of whether all tests were evaluated, the Canadian Forces might still be asked to speak to the common tasks and the criterion measures used for task performance.

A7.3 Evaluation of Tasks

In the first year of the study the actual task definitions as laid out in the list of seven common tasks were attempted. This did not prove satisfactory as individual differences in conditions, (i.e.,digging in soil), proved to be unreliable measures. Therefore, operational definitions were created for each task which improved the reliability of task measures considerably ($.93 < r < .99$). Nonetheless, the extent to which operational definitions could portray the true task performance was not consistent across all tasks. For example, the box dig removed strength and technique components which contributed to scores in the actual task performance. This may not have been as obvious in the land evacuation and other tasks. Nonetheless, with these improved operational definitions, fitness scores accounted for anywhere from 8% to 64% of variance in task performance data, depending on the task and the group. To improve the relationship to the point where results are predictive, it would be necessary to execute the tasks themselves.

A7.4 Determination of Passing Criteria

In this study an equal and representative number of men and women were used to determine the common passing criteria. As the correlations were relatively poor, the 75th percentile used as the common passing criteria was relatively insensitive to changes of 10% - 15%. This was especially true for men as the passing criteria tended to accept most men and only the upper half of women. If the requirement were raised where there would be a comparable impact on the male population then the female requirements would rise unreasonably high. This is because the tasks were designed with the preconceived notion of who would undertake the tasks as well as how the tasks should be performed. If the task definitions were strictly applied to women in the simple view of finding women who can meet a higher task criteria, this solution is pragmatic in the short term but does not go any distance towards equality.

It remains to be shown that the task has been designed in an optimal manner. Both the land evacuation and sandbag carry task definitions can be used to describe the importance of creating optimally-designed tasks prior to trying to screen individuals to meet task criteria. For example, the load on the land stretcher was fixed at slightly heavier than the average man's weight of 80 kg. As indicated earlier, this type of definition means that the women whose average weight is less than men are constantly carrying greater proportionate loads than their male counterparts. Therefore, it is reasonable to expect that the underlying fitness parameters also change between genders as the loads are not comparable between genders. In addition, this task was not modified to optimize the task. The simple addition of shoulder straps on the stretcher would have improved the task definition considerably for women and men, regardless of whether the load was changed. For the sandbag carry the bags were filled to 20 kg. The amount of sand in the bag is also an arbitrarily determined load. Perhaps both men and women would move more total sand if 15 kg per bag were used. Once again, no attempt to optimize task performance for both genders has been undertaken prior to determination of optimal fitness standards. It would seem logical that the Canadian Forces should first attempt to create optimal task definitions for men and women prior to the creation of screening tests.

A7.5 Minimum Physical Fitness Standard

The minimum physical fitness standard could be defined as: the lowest possible fitness level at which an individual may be reasonably expected to successfully undertake standing orders. Within this definition, "lowest possible fitness level" must be selected as the 5th percentile of passing groups fitness levels. The terms "reasonably expected" to succeed refers to the likelihood of success rather than failure on the task. As the variance in scores can be explained from 8% - 64% by EXPRES, depending on task and group, it would be reasonable to accept a fifty/fifty chance that the individual has an equal probability of passing or failing. This might be particularly appropriate for women seeing as the task definitions can be challenged. Perhaps a higher probability might be argued for the male standard of task performance seeing as sizes and weights of jobs were originally designed for men. Also within the definition is the term "successfully undertake standing orders." Success therefore depicts a pass and fail criterion. In our model we have determined 75% of the population as the level that should be considered a pass. This is essentially arbitrary but based on history and current practices. This entire definition rides on the assumption that all CF personnel in the Armed Forces in addition to their military duties have certain other occupational duties. For example, a CF member is also a clerk rather than a clerk who also has military duties. The only question that remains is, how reasonable are the standing orders.

A7.6 An Alternate Solution

One concept which has not been adequately explored is the idea that an individual often uses one attribute to compensate for another. For example if a person has a good aerobic capacity but reduced muscular strength, they may carry smaller loads but move more quickly. This information is available using the regression equations to predict task performance: $constant_1$ + $coefficient_1$ (grip score) + $coefficient_2$(VO_2 max). By using probability tables it would be possible to determine the likelihood of success at each of the tasks. In addition, the probability tables could be used to evaluate the impact by gender and age of moving the task performance criteria higner or lower. These tables would give the CF long term planning potential in terms of fitness levels and an opportunity to change some tasks in the battery and measure the impact of this change. In addition the CF would have the potential to accept the same or different probabilities of success by gender. This potential could be beneficial at this time in history in that social constructs and systemic bias in task design favour men. If the CF wished to accept differing probabilities of success as a compensation measure, then the effect of this decision could be measured prior to implementation. As barriers are removed, the probability of success could also be raised. This concept is explored with examples from Phase III data in Section C of this report.

A7.7 Technology Transfer

The information found within this contract reveals that further research must be continued in order to assess changes in task performance score resulting from fitness and to increase the confidence of the data base at hand. In addition we recommend that any CF personnel for whom sanctions are considered be given a final opportunity to redeem themselves by executing the tasks themselves.

We therefore encourage the Canadian Forces to establish a testing site to continue data acquisition. In addition, we propose that the Canadian Forces create a central computerized data base of EXPRES variables so that these measures may be monitored over time to assess the relationship between EXPRES, fitness, task performance and occupational trades.

A8 CONCLUSIONS AND RECOMMENDATIONS

The following statements represent our opinion of the findings from the experiments undertaken in this contract.

A8.1 Operational Definitions and Performance Criteria

The operational task protocols used in this study were sufficiently objective and reliable to be considered reasonable measures of task performance. Further, the selection of a task performance criteria set at the 75th percentile of the total sample population performance was based on realistic task requirements.

WE THEREFORE RECOMMEND THAT:

The Canadian Armed Forces continue to use operational task protocols rather than field task definitions and that the 75th percentiles should be continued as the passing criteria to evaluate performance.

Since the present protocols and standards are relative to the current populations sampled, these task criteria should be upgraded as CF personnel improve their fitness.

A8.2 Fitness Content in the Common Military Tasks

Across all tasks and groups, not less than 8% nor greater than 64% of task performance can be explained by measures of physical fitness. The remaining variance in the data is probably a result of factors such as motivation, skill, training and other unmeasured variables. Furthermore, it was evident that EXPRES variables which related to task performance differed among the three groups studied, (women under 35 years, women over 35 years, and men over 35 years of age) despite the fact that task performance requirements were identical for all three groups. (This result also occurred in previous phases of this study.)

WE THEREFORE RECOMMEND THAT:

EXPRES, which is a reasonable indicator of general physical fitness, continue to be developed as an indicator of task performance but, that the Minimum Physical Fitness Standards be established based on those fitness variables which relate to task performance for a particular group.

A8.3 Minimum Physical Fitness Standards for Women Under 35 Years

In our opinion the EXPRES scores listed in Table A14 reasonably represent the 5th percentile of this female population sample under 35 years of age able to pass the performance criteria established for the common military tasks. However, this sample may not adequately represent the total population since there was a disproportionate number of subjects with excellent grip strength.

WE THEREFORE RECOMMEND THAT:

Minimum Fitness Standards be established for women under 35 years of age based on a combination of data from the sample populations observed in MPFS II and MPFS III and shown in Table A18.

A8.4 Safety Restriction for Older Subjects

Compliant with the American College of Sports Medicine, no CF personnel over thirty-five years of age was permitted to execute tasks at maximal heart rate. This safety restriction modified the MPFS task protocols for older subjects.

A study was undertaken to compare a restricted and unrestricted task performance. Results revealed that the constrained protocols restricted performance on the average 32%. The task performance criteria were adjusted to accommodate for this restriction.

WE THEREFORE RECOMMEND THAT:

Restricted task protocols continue to be used during subsequent data acquisition phases, however, if sanctions are imposed against an individual,

Table A18 Recommended Canadian Forces Minimum Physical Fitness Standards based on results from three phases of data acquisition for predesignated common tasks.

	Men <35 years	Women <35 years	Men ≥35 years	Women ≥35 years
Maximum Grip (kg)	75	50	73	48
VO_2 max (ml/kg/min)	39	32	35	30
Sit-ups (#)	19	15	17	12
Push-ups (#)	19	--9*	14	--7*
ILM (kg)	--	25	35	20

we recommend that unrestricted task protocols be conducted in the presence of medical support.

A8.5 Minimum Physical Fitness Standards for Women Over 35 Years

The EXPRES scores listed in Table A14 and A18 reasonably represent the 5th percentile of the female population sample over 35 years of age able to pass the performance criteria established for the common military tasks. Although this sample of older women was smaller and only one sample was tested, it was representative of a wide range of fitness levels.

WE THEREFORE RECOMMEND THAT:

A Minimum Fitness Standard for older women be established based on results in Table A18.

A8.6 Minimum Physical Fitness Standards for Men Over 35 Years

The EXPRES scores listed in Table A14 reasonably represent the 5th percentile of the male population sample over 35 years of age able to pass the performance criteria established for the common military tasks. However the population sample tends to represent individuals in the good to excellent fitness classifications and is skewed to a lower minimum by combination with older women's data.

WE THEREFORE RECOMMEND THAT:

A Minimum Fitness Standard for older men be established based on a combination of data from the two sample populations observed in MPFS II and MPFS III as shown in Table A18.

A8.7 Permanent Testing Facilities

After two years of refinement, MPFS protocols and systems for data processing are now consolidated.

WE THEREFORE RECOMMEND THAT:

A technology transfer phase be implemented and that a permanent testing facility be constructed at a CF Base to routinely upgrade these criteria as well as to further evaluate individuals who fail to achieve MPFS fitness criteria.

SECTION B

DETAILED EXPERIMENTAL REPORTS

SECTION B1

ANTHROPOMETRIC, EXPRES AND LABORATORY DATA ANALYSIS

B1 ANTHROPOMETRIC, EXPRES AND LABORATORY DATA ANALYSIS

B1.1 Introduction

This section describes the military personnel according to EXPRES, the CF anthropometric and fitness test battery and selected laboratory tests. The anthropometric measures and EXPRES data consisted of height, weight, selected girth measurements, percent body fat and the EXPRES measures of muscular endurance in sit-ups and push-ups, aerobic endurance (a predictive sub-maximal step test) and muscular strength (a combined hand grip score). The laboratory tests included endurance hand grip, endurance upper body flexed arm hang and maximal Incremental Lifting Machine (lift to 1.80 m). The number of tests which were included in this report have been reduced in number based on results from Phase I and Phase II, where correlations were sufficiently low to remove specific items from the battery. The purpose of this test battery was to profile each subject according to fitness in order that these data might be used in developing minimum physical fitness levels required for satisfactory performance of the Military tasks (Sections B2 to B6).

B1.2 Subjects

A total of 149 subjects participated in Phase III at Queen's University from August 4 to August 21, 1987. The subjects were transported in from various CF bases, most frequently CFB Kingston, Trenton and Ottawa as well as NDHQ in Ottawa. The original request for subjects was to test 80 younger women and older men, 20 from each quartile of EXPRES oxygen consumption score, and 40 older women, 20 from each half of the oxygen consumption percentiles. The intent of requesting subjects from varying fitness levels was to guarantee a representative sample and ensure that the fitness standards were not skewed by either testing a very unfit group or a very fit group of individuals. The younger women and older men's groups represented a second independent sample of military personnel so that minimum fitness standards could be developed based on two representative samples. The older women's group had not been previously tested, except for a small group of 8 women in Phase II. As this sub-group represents a very small percentage of the total military population, it was difficult to repeat the tests on a second sample.

B1.3 Procedures

Upon arrival at Queen's University, subjects were given an initial briefing by an officer from DPERA and the project manager from Queen's University. Subjects were then provided with a short tour of the testing facilities, shown accommodation and provided with lunch. Upon return, a formal briefing on the purpose of the study was held which addressed such matters as; a review of the test and task batteries, assurance of confidentiality, safety and general procedures. Subjects were divided into small groups and rotated in a circuit through all 6 stations. See Appendix B for subject information booklets.

Only 1 test item was performed in each half day in order to reduce and control levels of fatigue. Each testing station had specific personnel who remained at that station throughout the testing week in order to control supervisor impact. Leaders at each project station used a written manual of protocol for each task, read the protocol to subjects and provided demonstrations and practice time prior to each task. Leaders tried to remain consistent in encouragement, reinforcement and protocol requirements.

The American College of Sports Medicine Guidelines (85: 39-42) clearly states that persons greater than or equal to 35 years of age should not sustain an exercise intensity in excess of 90% of maximal capacity. As a consequence, in the present study, in the interest of safety subjects 35 years of age or older were required to wear heart rate monitors throughout testing in order to monitor their on going heart rate changes. 90% capacity was determined by heart rate response as predicted by the following equation and pre-programmed into each heart rate monitor: 90% heart rate = 0.9[(220-age)-70] + 70 bpm; where 70 bpm is assumed to be the resting heart rate. When the subjects ≥35 years of age achieved their predicted 90% of capacity limit, they either discontinued that exercise, or paused until their heart rate recovered sufficiently to allow them to proceed at the low 90%. In other words, these subjects ≥35 years were not given the freedom to complete the tasks and tests as vigorously as younger subjects, often having to pace themselves throughout the longer task performances. Therefore, data for older subjects were analysed separately from younger groups and the findings interpreted in this light. Throughout section B, specific instances are highlighted and discussed accordingly.

There were approximately 12 subjects per group and each group rotated through 6 stations during their week at Queen's University. 5 stations consisted of tasks, namely Low-high Crawl, Land Evacuation, Sea Evacuation, Entrenchment Dig and Sand bag Carry and the additional laboratory test stations consisting of Flexed Arm Hang, Endurance Grip and Freestyle ILM. The EXPRES data had been administered by qualified CF Physical Education and Recreation Instructors (PERI) not less than 6 months prior to testing subjects in the tasks. The oxygen consumption score from the EXPRES test was also used as the criteria for selection of a representative and random group of subjects.

B1.4 Results and Discussion

B1.4.1 Physical Characteristics of the Subjects

The sample consisted of a total of 149 subjects comprised of 59 women <35 years, 28 women ≥35 years and 62 men ≥35 years of age. Means, standard deviation and ranges of all subjects in Phase III are divided by age and gender in Table B1.1. The characteristics of age, height and weight of the sample population were representative of military normative data. A significant difference was noted between height and weight variables across gender, though not in regard to age. The younger women in Phase III were similar in age, height and weight characteristics to other phases. However, the older men and women categories contained a subject pool approximately three years older than the previous phase and older women were 5.4 kg heavier than the previous sample.

B1.4.2 Sample Distribution by EXPRES

The distribution of the subjects on the basis of EXPRES percentile scores is shown in Table B1.2 with descriptive data in Figure B1. Subjects had been requested at random but within quartiles of fitness scores based on oxygen consumption values. For women under thirty-five years, the sample was evenly distributed in oxygen consumption but skewed positively in combined grip and negatively in push-ups. However, for older women there was a preponderance of subjects who fell in the excellent category, in oxygen consumption and grip, although some subjects were distributed in lower fitness levels. The sit-up scores were well distributed, but push-ups were negatively skewed. For older men there was a large grouping at excellent and below average categories for oxygen consumption, but subjects were skewed positively for all other fitness categories.

There would be a natural tendency for more fit subjects to volunteer for physically demanding tasks. Unfortunately, this natural selection process tended to render higher prediction values of MPFS. As the subjects were selected based on oxygen consumption values, it was not possible to account for grip, push-up or sit-up scores. If a larger sample were selected for study then it would be anticipated that all EXPRES variables would become

Table B1.1 Distribution of CF personnel by sex and age level.

	Under 35 years n	Over 35 years n	Total
Women	59	28	87
Men	--	62	62
Total	59	90	149

Table B1.2 Population Distribution by EXPRES Percentiles based on Military Normative Data. Values indicated are the counts observed in each category.

Test Variables	Women < 35 Years	Women ≥ 35 Years	Men ≥ 35 years
OXYGEN CONSUMPTION (ml/kg/min)			
Excellent	11	12	27
Good	14	6	4
Average	11	4	9
Below Average	12	3	15
Poor	11	3	7
COMBINED GRIP (kg)			
Excellent	32	1	29
Good	14	10	10
Average	4	4	14
Below Average	7	4	6
Poor	2	9	4
SITUPS (no.)			
Excellent	17	6	22
Good	6	5	15
Average	10	9	15
Below Average	11	6	3
Poor	15	2	8
PUSHUPS (no.)			
Excellent	4	1	23
Good	0	1	13
Average	5	2	10
Below Average	8	4	10
Poor	42	20	7

Excellent - 81-100 %ile
Good - 61-80 %ile
Average - 41-60 %ile
Below Average - 21-40 %ile
Poor - ≤20 %ile

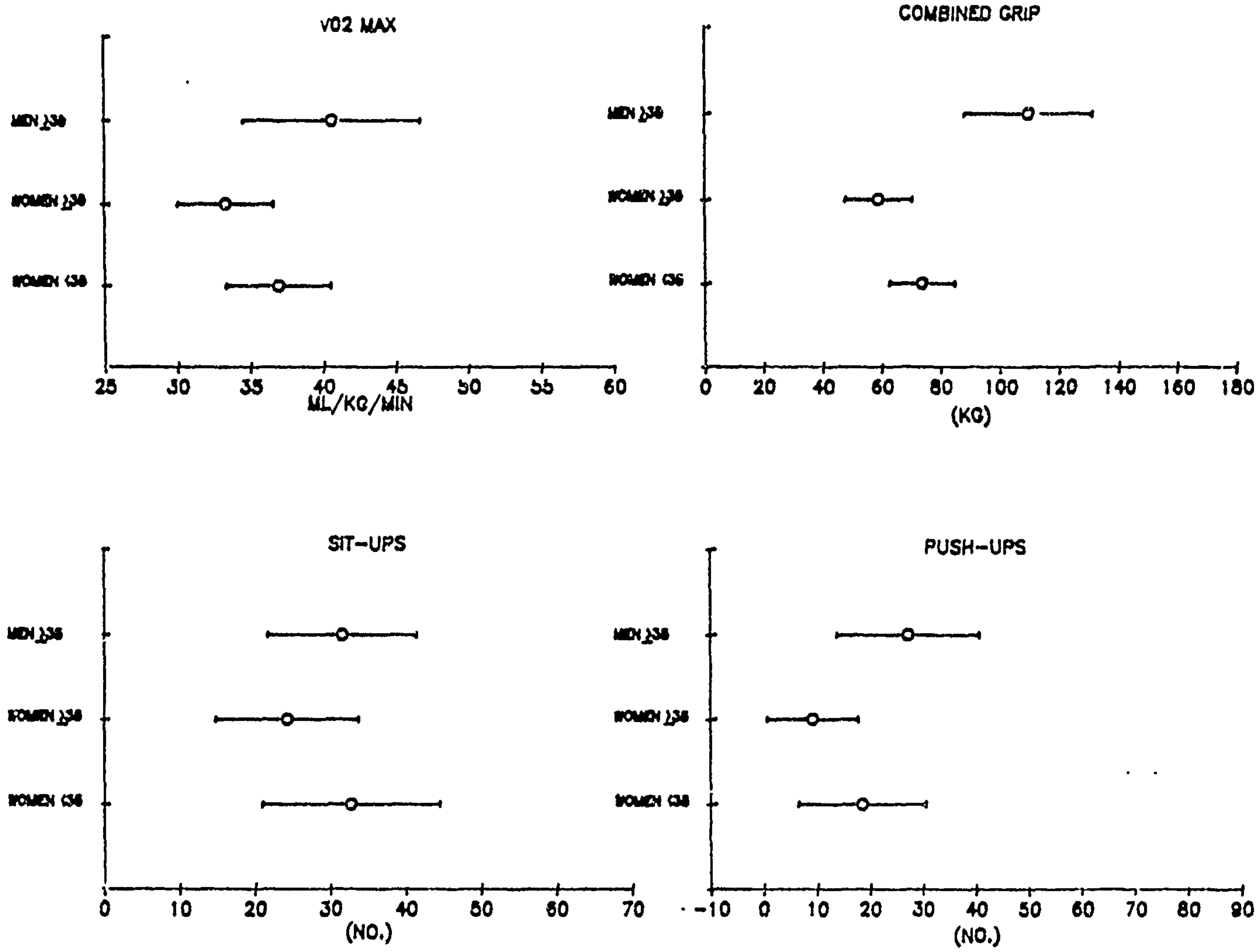

Figure B1. Graphic display of EXPRES scores of the sample by age and group. The o represents the mean scores and the bar represents one standard deviation.

normally distributed.

The push-up data were skewed toward the poor category for both younger and older women. Between Phase II and Phase III, a push-up similar to the men's push-up was implemented for women. When comparing data from Phase I and II, where push-up scores were excellent and normally distributed respectively using the knee style push-up, Phase III data would indicate that the preponderance of poor push-up scores were highly questionable for establishment of a standard.

The EXPRES data for the three groups are plotted for comparison (Figure B1) and the actual EXPRES scores by age group and sex for the sample population are presented in Table B1.3. With all EXPRES variables older men have higher scores than younger women who also have higher mean scores than older women. This tendency would be expected based on the normative data by gender and age. The only variable which did not follow this trend was sit-ups, where younger women had a slightly higher mean score than older men. Both sit-ups and push-ups should naturally adjusted by one's own body weight hence the impact of body size was not as obvious. This was not evident in the push-up scores, where women were asked to execute a different push-up between Phase II and Phase III. The drop-off in MVO_2 was expected by gender and age, and combined grip scores, responded to body mass as well as age.

B1.4.3 Summary of Laboratory Tests

Based on previous reports, three additional laboratory tests were included in the test battery; namely, flexed-arm hang, combined endurance grip, and free-style maximal Incremental Lifting Machine (ILM) lift. These data are plotted in Figure B2 and reported in Table B1.4. In all cases older men had higher scores for all three variables than younger and older women. Younger women had higher scores than older women on flexed arm hang

Table B1.3 Summary of EXPRES scores of the sample by age group and sex.

	Predicted VO2MAX	Combined Grip (kg)	Situp (no.)	Pushup (no.)
Women < 35 years n= 59				
Mean	36.9	73.2	32.7	18.4
SD	3.6	11.2	11.8	12.1
(min-max)	(30.4-50.2)	(43-98)	(7-59)	(0-70)
Women ≥ 35 years n= 28				
Mean	33.3	58.6	24.3	9.1
SD	3.3	11.4	9.5	8.6
(min-max)	(27.5-39.8)	(37-80)	(4-42)	(0-35)
Men ≥ 35 years n= 62				
Mean	40.6	109.5	31.6	27.1
SD	6.1	21.8	9.9	13.5
(min-max)	(30.4-57.8)	(14-159)	(8-62)	(5-81)

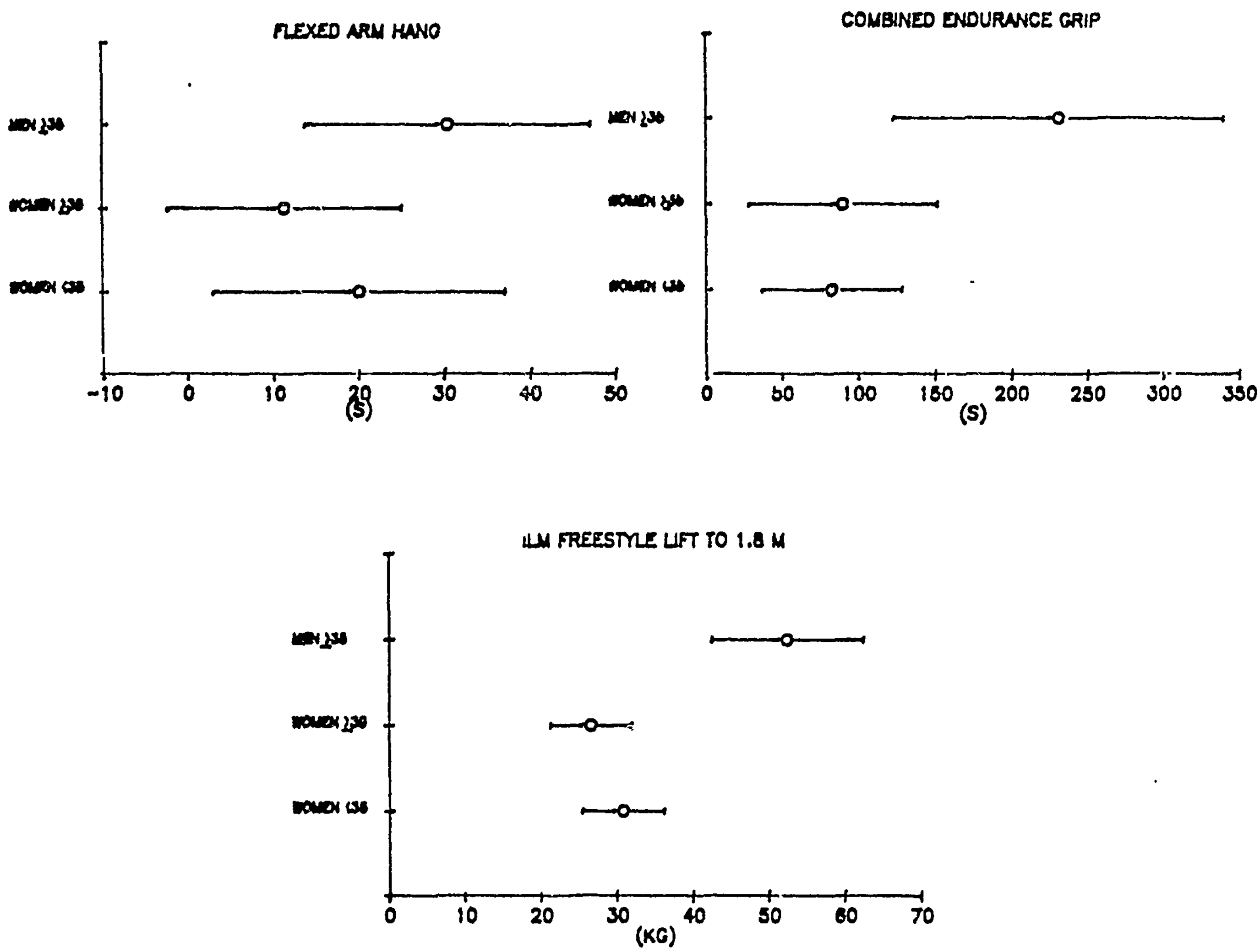

Figure B2. Graphic display of laboratory test scores of the sample by age and group. The o represents the mean scores and the bar represents one standard deviation.

Table BI.4 Summary of Laboratory Test Scores of the Sample by Age Group and Sex.

	Flexed Arm Hang (s)	Combined Endurance Grip (s)	ILM Freestyle Lift to 1.8m (kg)
Women < 35 years n= 59			
Mean	20.0	82.4	30.8
SD	17.1	46.2	5.4
(min-max)	(0-62)	(15-203)	(20.0-55.0)
Women ≥ 35 years n= 28			
Mean	11.3	89.8	26.6
SD	13.7	62.0	5.4
(min-max)	(0-45.8)	(25-275)	(20.0-42.5)
Men ≥ 35 years n= 62			
Mean	30.4	231.2	52.4
SD	16.7	108.6	10.0
(min-max)	(2.2-76.1)	(59-547)	(35.0-80.0)

and ILM lift; however, endurance grip was greater, although not significant, for older women. When comparing tests across groups and years, the sample of younger women for Phase III were higher on all test categories than women from the previous phase. This result paralleled the EXPRES data across younger women. The opposite effect was true for older women in that the small sample (n = 8) in Phase II were elite women, whereas this sample was larger (n = 28) and more widely distributed. Likewise, the older men were less proficient at flexed-arm hang and combined grip in comparison to the previous year. This followed the profile of older men on the EXPRES test, where all scores were lower except for maximal combined grip.

The ILM test could not be compared between phases because a freestyle ILM lift was incorporated in this Phase III. A freestyle lift was selected as this test is being considered in recruiting stations as an indicator of strength. For all groups the lift scores were higher than previous years. This was to be expected as subjects were permitted to (usually at the wrist change-over point) and continue upward to 1.8 m. The difference in ILM scores from Phase II to Phase III for younger women, older women and older men, were 7.0 kg, 4.1 kg, and 7.3 kg, respectively. The higher scores on ILM tests across all groups, indicated that the previous protocol lowered the ILM scores. In Phase III, the less restrictive freestyle protocol allowed subjects to improve their ILM score; this occurred despite the fact that the structure of the ILM required a unique manoeuver not found in actual lifting tasks. The ILM freestyle lift has been performed on 149 subjects in this study, and no incidents of injury resulted. This would indicate that the ILM test protocol was safe for all subjects.

B1.4.4 Summary of Field Tasks

Table B1.5 presents the summary of field tasks by sex, group and age levels. In performance of the tasks, older men completed them more quickly

Table B1.5 Summary of field tasks by sex and age level.

	Land Evacuation Total time (s)	Low-high Crawl Total time (s)	Entrenchment Dig Total time (s)	Sea Evacuation Total time (s)	Sandbag Carry Total # bags carried
Women < 35					
Mean	771.6	144.1	498.2	148.0	12.2
SD	226.4	43.0	135.7	158.3	2.0
(min-max)	(445-1656)	(64.6-295.3)	(256-953)	(27-747)	(7-18)
Women ≥ 35					
Mean	960.3	212.0	630.5	259.5	9.5
SD	297.6	66.6	180.4	244.1	1.4
(min-max)	(470.5-1607)	(86.1-355.8)	(373-1081)	(36-912)	(8-12)
Men ≥ 35					
Mean	582.9	122.2	408.9	40.1	12.1
SD	167.5	56.8	136.6	15.1	2.6
(min-max)	(288-1084)	(58.7-330.7)	(216-809)	(21-97)	(8-19)

than younger women, despite being restrained with heart rate monitors. Similar significant differences were found between younger and older women, probably due to the heart rate restriction. However, individuals differed widely as suggested by the standard deviations in the data. A graphic presentation of the tasks is provided in Figure B3. These histograms show the extent of overlap between older males and females (age groups combined). It is noted that the overlap on task performance resembled more closely the overlap in VO_2 max and sit-ups scores, rather than push-ups, grip and ILM scores (see Figure B1 and B2).

Comparing Phase II with Phase III data younger women, differences in the entrenchment dig, sea evacuation, low high crawl and sand bag tasks were small (12.6 s, 12.5 s, -5.3 s and +1 respectively). The land evacuation task could not be compared as the course length had been changed from 1 km to 750 m. Older women required slightly longer (1.5-2.5 min) on tasks than the small group of elite women in Phase II. The older men in Phase III were faster in low high crawl, entrenchment dig and sea evacuation than men from Phase II (9.0 s, 50.8 s, 34.8 s respectively). This was probably a result of a more fit sample, as determined by EXPRES, than in the previous year.

B1.5 Conclusions

The fitness testing carried out in the present study profiled 3 military groups: female personnel less than 35 years (N=59), female personnel greater than 35 years (N=28) and male personnel greater than 35 years (N=62). In general, each sub-group was representative of their respective CF population when compared to military EXPRES normative data, except for younger women whose combined grip scores were skewed to the excellent and good categories and push-ups for younger and older women which were skewed toward to poor fitness category.

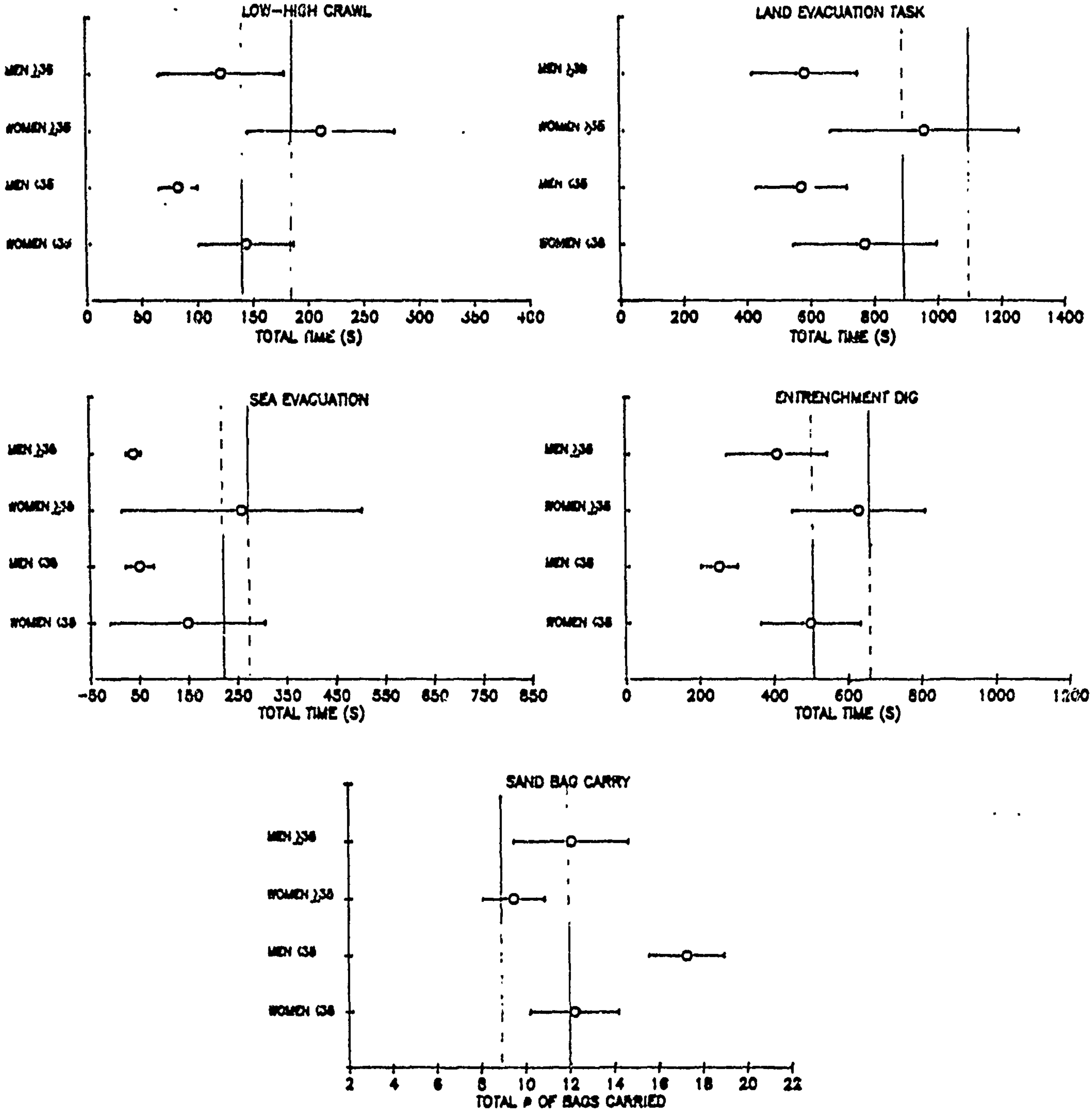

Figure B3. Graphic display of field task scores of the sample by age and group. Data for men <35 years from Phase II has been included to present a clearer understanding of all groups. The o represents the mean scores and the bar represents one standard deviation.

The push-ups required of women wa   .nged between Phase II and III, such that most women were very inexperienced in this style of push-up. As a result, 42 of the 59 younger women and 20 of the 28 older women were in the poor category of push-ups measures based on male normative data. Time and experience will be necessary to compile representative data for women with the full body push-up. Until that time, no interpretation of push-up data will be possible.

SECTION B2

LOW HIGH CRAWL TASK ANALYSIS

SECTION B2

LOW HIGH CRAWL TASK ANALYSIS

B2.1 Introduction

Simulating a combat situation where personnel were pinned down by enemy fire, completion of this emergency task required that two crawling techniques be employed: through the initial 30 m of the course a low (leopard) crawl technique was required, then over the final 45 m a high (kitten) crawl on hands and knees. A major error in technique noted in performance of this task during Phase I was subjects' leopard crawl. On the majority of trials subjects actually did not perform the low crawl or performed it very poorly, raising too high off the ground (Stevenson et al., 1985). Thus, the task protocol was modified for Phase II with the placement of 16 barriers (45 cm in height; width 180 cm) at 2m intervals along the initial 30m of the course which forced subjects to perform the low crawl in a technically correct fashion (Stevenson et al., 1986). This modification was carried through into the present phase with the barriers again being placed over the low course. As well for Phase II, and with agreement of DCIEM and ranking CF personnel, the pass/fail criteria for completion of the low high crawl was revised upwards, from 90 seconds to 134 seconds (see Stevenson et al, 1986: pp. 26 - 35); this emendation was also retained in the Phase III.

B2.2 Task Rationale

Published research quantifying the physical components of crawling does not exist. In previous studies conducted by the present investigators (Stevenson et al, 1985 & 1986) the low high crawl was shown to be very physically demanding: maximal heart rate response and near-maximal blood lactate post-exercise were elicited confirming both the task's high aerobic and anaerobic energy requirements. Unfortunately, since the physiological response is near-maximal in all subjects these parameters correlated very poorly with task performance (Stevenson et al., 1985).

For both Phase II and III (the present phase) several protocol modifications were instituted to improve test objectivity and subject assessment on this task. Most significantly, barriers low-to-the-ground were placed over the low crawl portion of the course which proved effective in forcing subjects to perform the leopard crawl correctly. As a result, however, total time for completion of this task was lengthened. During Phase II 75% of subjects equaled or bettered 134 seconds, therefore, this time was established as the new pass /fail criterion for the task, revised upwards from the CF's original time criteria which was based upon the U.S. Marines' elite standard for combat personnel. In addition, during MPFS II split-times were recorded at intervals along the course as subjects progressed through the low and high crawl portions; these time splits were also recorded during the present phase of testing.

And for the first time, in Phase III the course itself was moved indoors. During Phase I and II this task was performed outside on grass, however this imposed several constraints upon our testing of subjects. Foremost, lush turf could not always be secured at the various test sites; on the other hand, when such an area was made available it often proved too slippery for some subjects to secure elbow- and toe-holds, inhibiting their low crawl performance particularly. And later, this surface would become scarred and unsightly unless the entire course was rotated about the grassy area every half day of testing. As well, inclement weather would worsen existing conditions, on occasion even forcing cancellation of a half day of testing. Therefore, for the present phase this task was conducted inside the Queen's University arena with subjects crawling over a firm, yet soft, 2 m wide, rubberized runway.

Finally, because of the rigorous physical nature of this task, during performance of the low high crawl subject care and safety was paramount. Therefore, it was required of subjects to dress in military fatigues, and pad their elbows and knees securely with the result that some subjects felt somewhat restricted by their attire. Moreover, for subjects $\geq$35 years, their heart rates were continually monitored as a safety precaution. Because of the strenuous nature of this task, many of these subjects were forced to pace themselves throughout their performance such that their heart rate remained <90% predicted maximal; if not, these personnel were stopped and not permitted to continue. In either circumstance their performance times were affected accordingly.

B2.3 Task Protocol

This task simulated a combat situation where personnel are pinned down by enemy fire. The task required the subject to crawl through a 75 m course: through the low course, the initial 30 m, employing leopard crawl technique; turning 180°, on hands and knees, reversing direction; then over the high course, the final 45 m, coming back (alongside and parallel to the low course portion) to the finish line employing kitten crawl technique. Over the low course a chute was constructed by placing a series of 16 barriers a 2 m intervals, wooden crossbars 45 cm off the ground, each supported by two metal posts aligned 180 cm apart (see Appendix C). For the first time, in the present phase this task was conducted indoors over a runway of rubberized mats laid over the arena floor at Queen's University.

In full combat gear, including helmet, fatigues, carrying rifle (but with elbows and knees padded to prevent abradement), the subject started in a prone position, elbows, stomach, thighs and knees on the ground, the hands or arms supporting a (simulated) C7 rifle (i.e., the latest CF issue duplicated in shape, size and weight for this study). On the command "go" the subject began a leopard crawl for 30 m, moving through the chute, the elbows and insides of the knees and boots gripping the rubberized runway for traction. At 30 m the subject rose to hands and knees, turned 180 degrees, then began a kitten crawl for 45 m to the finish line; during the high crawl personnel grasped the rifle in one hand (around its barrel or stem) lugging the rifle along with them.

The variables recorded were total time (in seconds) through the course, as well as the following split-times: through the low portion, at 20 m and at completion at 30 m; through the high portion, at 50 m and at completion at 75 m.

B2.4 Results

B2.4.1 Descriptive Results

In Table B2.1 total times for completion of the low high crawl task and subjects' split-times are presented. On average, men ≥35 years completed the course in a faster time (just under 2 minutes) than the female groups, and this trend was also reflected in their split-times through the course. Women <35 years completed the course on average in 2.4 minutes, while the women ≥35 years required 3.5 minutes to complete the task. However, the range of times for both the men and women's groups was noteworthy. The fastest males ≥35 progressed through the course just seconds faster than several of the females <35 years; counterpoised, split-times and total times of the slowest males ≥35 were only seconds faster than several of the female subjects ≥35 years. Overall, there was considerable overlap between the groups both in their total times for completion of the task and the various split-times through the course.

B2.4.2 Simple Correlations

The three B2.2 Tables present correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to these performance times:

Table B2.1 Summary of Low High Crawl Performance of the Sample by Age Group and Sex.

	Low Crawl Time (s)		High Crawl Time (s)		Total Time (s)
	0-20 m	Total Time	0-20 m	Total Time	
Women < 35 years n= 59					
Mean	49.3	82.5	31.7	61.5	144.1
SD	18.1	30.6	7.6	14.7	43.0
(min-max)	(18.3-111.3)	(28.0-178.8)	(16.9-58.6)	(36.6-116.5)	(64.6-295.3)
Women ≥ 35 years n= 28					
Mean	76.3	127.6	44.6	84.4	212.0
SD	28.1	45.8	12.7	24.8	66.6
(min-max)	(25.2-132.0)	(40.0-222.3)	(20.9-68.0)	(46.1-133.5)	(86.1-355.8)
Men ≥ 35 years n= 62					
Mean	39.4	62.1	31.9	60.0	122.2
SD	23.1	35.2	17.3	24.7	56.8
(min-max)	(16.5-140.9)	(26.6-203.3)	(15.0-98.1)	(28.4-143.1)	(58.7-330.7)

Table B2.2a Correlations Between Low High Crawl Performance Measures and Fitness Parameters by Sex and Age Level: Total Time.

	Women <35	Women ≥35	Men ≥35
Anthropometry			
Age	.32	-.06	.30
Height	.08	-.09	-.07
Weight	.31	.46	.37
Muscular Strength and Endurance			
Situp	-.41	-.37	-.52*
Pushup	-.47*	-.10	-.38
Combined Grip	-.22	-.34	.09
Endurance Grip	-.27	-.49	-.21
Flexed Arm Hang	-.59*	-.64*	-.49*
Maximum ILM to Full Extension	-.46*	-.20	-.18
Aerobic Capacity			
Step test	-.51*	-.56	-.46*

Note. * $p<.001$.

Table B2.2b Correlations Between Low Crawl Performance Measures and Fitness Parameters by Sex and Age Level: Low Crawl.

	0-20 m			Low Crawl Total Time		
	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35
Anthropometry						
Age	.32	.05	.24	.31	.01	.30
Height	.16	.01	-.03	.15	-.003	-.05
Weight	.34	.48	.31	.34	.51	.33
Muscular Strength and Endurance						
Situp	-.37	-.31	-.46*	-.41	-.35	-.49*
Pushup	-.46*	-.07	-.33	-.46*	-.09	-.36
Combined Grip	-.15	-.27	.04	-.18	-.24	.06
Endurance Grip	-.19	-.39	-.15	-.22	-.38	-.16
Flexed Arm Hang	-.52*	-.57	-.38	-.57*	-.60	-.41
Maximum ILM to Full Extension	-.35	-.20	-.21	-.40	-.23	-.20
Aerobic Capacity						
Step test	-.48*	-.50	-.41	-.49*	-.52	-.43

Note. * $p < .001$.

Table B2.2c Correlations Between Low High Crawl Performance Measures and Fitness Parameters by Sex and Age Level: High Crawl.

	0-20 m			High Crawl Total Time		
	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35
Anthropometry						
Age	.23	-.27	.26	.28	-.18	.27
Height	-.03	-.13	-.04	-.08	-.24	-.08
Weight	.24	.21	.34	.19	.28	.37
Muscular Strength and Endurance						
Situp	-.28	-.25	-.45*	-.35	-.35	-.50*
Pushup	-.39	-.06	-.30	-.43	-.11	-.35
Combined Grip	-.27	-.45	.12	-.25	-.48	.13
Endurance Grip	-.31	-.61	-.23	-.34	-.62*	-.24
Flexed Arm Hang	-.54*	-.64*	-.50*	-.55*	-.62*	-.54*
Maximum ILM to Full Extension	-.48*	-.10	-.10	-.51*	-.10	-.14
Aerobic Capacity						
Step test	-.51*	-.44	-.39	-.46*	-.54	-.45*

Note. * $p<.001$.

specifically, total time over the course, Table B2.2a; low crawl times, Table B2.2b; and high crawl times, Table B2.2c. As seen from Tables B2.2a and B2.2b, including all subjects men and woman, only 15 r-values of the total of 63 fitness-related coefficients were found to be significant at the (accepted) 0.001 level of confidence, while many approached zero (i.e., 15 coefficients within -0.10 to +0.10 range in Tables B2.2a & .2b). In Table B2.2c however, while the number of significant r-values was again small (only 14 of 42 fitness-related coefficients).

The r-values relating flexed arm hang time and each group's high crawl split-times were all significant ($p<0.001$). Further, re-examining Tables 2B.2a and 2B.2b, each group's flexed arm hang-time and their total time for the low high crawl were also found to be significant (Table 2B.2a), as were hang-time and low crawl split-times for women <35 years (but not for the other two groups in this latter instance, see Table B2.2b). In all, 11 (of these 15) r-values proved to be significant, ranging from -0.49 to -0.64. Lastly, in Tables B2.2a-.2c, of the 105 coefficients calculated, 100 were determined to be <u>negative</u> values (i.e., the higher one's fitness test score, the shorter their crawl times); reciprocally, the highest positive r-value was calculated to be only +0.13 (see combined grip, Table B2.2c).

B2.4.3 Stepwise Regressions

Results of stepwise regression analyses of low high crawl total time on EXPRES and laboratory test variables are shown in Table B2.3. For men ≥35 years, both their sit-ups and flexed arm hang appeared as significant predictor variables but accounted for only 35% of the variance in total time. On the other hand, for the women, stepwise regression produced three reliable variables in their prediction equations: flexed arm hang, then VO_2max were common to both, with the third variable for women <35 years being their ILM lift and for women ≥35, EXPRES pushups. In this instance, these combinations

Table B2.3 Stepwise Regression of Low-High Crawl total time on fitness parameters by sex and age level.

Variables in Equation	B	SE B	Mult. R.	R^2	F	p
Women < 35 years						
Constant	392.03	55.66				
Flexed Arm Hang	-.91	.30	.58	.34	26.56	.001
VO_2 Max	-4.0	1.31	.64	.41	17.91	.001
ILM	-2.66	.89	.71	.50	16.80	.001
Women ≥ 35 years						
Constant	500.97	93.16				
Flexed Arm Hang	-2.82	.79	.63	.40	13.76	.001
VO_2 Max	-8.48	2.91	.73	.53	11.31	.001
Pushups	2.70	1.51	.80	.64	11.08	.001
Men ≥ 35 years						
Constant	233.86	22.77				
Situps	-2.60	.82	.54	.29	23.0	.001
Flexed Arm Hang	-.93	.43	.59	.35	14.65	.001

of variables accounted for 50% and 64% of the variance for young and older (respectively) in total time. In Table B2.4, blocked regression analyses are presented, with total time for the low high crawl regressed on fitness variables when the latter were blocked according to the major fitness components (i.e., muscle strength-endurance and aerobic capacity). For women ≥35 years none of the fitness components provided reliable relationships (at the accepted 0.001 level). By contrast, for woman <35 years, the greatest change in R^2 (0.34) was accounted for by their strength-endurance component when compared to other variables in the equation, while for the men ≥35 years their strength-endurance component accounted for a much smaller R^2 change (0.20).

B2.4.4 Criteria for passing the task

In Phase II of the study, the passing criteria was set at the 75th percentile of the population based on a sample of young men and women. The original passing criteria identified in Phase I was arbitrarily set at 90 seconds, the U.S. Marine Standard. In this phase only 72.5% of men and 15% of women could reach this standard. In Phase II using a representative and almost equal sample of younger men and women the standard was readjusted to 134 s, which was the 75th percentile of this population. At this position, 95% of young men and 56% of women passed the criteria. As this years sample was primarily older subjects, an adjustment was made to correct for the 90% restraint condition applied to older subjects. An equal sample of older men and women were pooled to determine the 75th percentile score. The time standard was set at 172 s which was 32% longer than younger subjects. This seemed reasonable based on a sub-study of 16 older men and 13 older women, where the restraint was 36.2% and 31.0% respectively. This restraint was obvious by observing the pacing required to keep heart rates below 90% maximal

Table B2.4 Low-High Crawl total time regressed on EXPRES and other laboratory tests blocked for fitness components

Block	R^2 Eqn.	F Eqn.	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	.22	4.38	.01	.22	4.38	.01
Strength and Endurance	.56	5.81	.001	.34	5.32	.001
Aerobic Capacity	.61	6.19	.001	.05	4.76	.05
Women ≥ 35 years						
Anthropometric	.32	2.63	NS	.32	2.63	NS
Strength and Endurance	.70	2.87	NS	.38	2.36	NS
Aerobic Capacity	.81	4.30	.05	.11	5.83	NS
Men ≥ 35 years						
Anthropometric	.23	5.23	.01	.23	5.23	.01
Strength and Endurance	.42	3.85	.001	.20	2.66	.05
Aerobic Capacity	.42	3.39	.01	.00003	.002	NS

levels. However the target time for younger subjects remained at 130 seconds. This target time divided the groups into passing and failing groups for the low-high crawl task.

B2.4.5 Discriminant Analysis

Discriminant function analysis (Table B2.5) using a stepwise procedure (testing both EXPRES and the other fitness variables) indicated very similar patterns of discriminating variables for the female subjects. For both groups of women, <35 years and ≥35, the same three variables were identified: VO_2 max, EXPRES pushups, and their ILM lift; as well, for women <35 years their flexed arm hang was also identified, while for the latter group endurance grip was a fourth fitness variable identified. In each case 80% and 86% of subjects in the respective groups were correctly classified, however, only for women <35 years was the function found to be significant at the 0.001 level of confidence. On the other hand, for men ≥35 years, only one variable appeared in their discriminant function (i.e., EXPRES sit-ups), and while this identified 93% of these subjects the function itself was found to be non-significant ($p<0.001$); that is, it could not reliably discriminate between the 'passers' and 'failers' for this group.

B2.4.6 Fifth Percentile of Passing Group

Table B2.6 represented the EXPRES and laboratory test scores normalized to z-scores which represent the 5th percentile of the passers for each group. The results of simple correlation, regression analysis and discriminant analysis are marked with superscripts. The 5th percentile value was representative of a normalized distribution score based on the passers of the task. Results of Table B2.6 can be summarized as follows:

1. Traditionally, minimum grip required for women has been found to be one-half of the grip minimum for men, and the values for the men ≥35

Table B2.5 Discriminant Analysis and Classification Results by EXPRES and Queen's Variables in Groups Defined by Low-High Crawl Pass Fail Status.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	%	Predicted Performance Correctly Classified n	%	Incorectly Classified n	%
Women < 35 years								
VO_2 Max	0.65	Pass	32	(54)	29	(91)	3	(9)
Pushups	0.31	Fail	27	(46)	18	(67)	9	(33)
ILM	0.24							
Flexed Arm Hang	0.41							
		Total	59		47	(80)	12	(20)
Wilks' Lambda:	0.53							
Chi-Squared:	34.91							
Significance Level:	0.001							
Canonical Correlation:	0.69							
Women ≥ 35 years								
VO_2 Max	0.88	Pass	20	(71)	18	(90)	2	(10)
Pushups	-0.55	Fail	8	(29)	6	(75)	2	(25)
ILM	0.38							
Endurance Grip	0.63							
		Total	28		24	(86)	4	(14)
Wilks' Lambda:	0.61							
Chi-Squared:	11.91							
Significance Level:	0.05							
Canonical Correlation:	0.63							
Men ≥ 35 years								
Situps	1.0	Pass	57	(93)	54	(95)	3	(5)
		Fail	4	(7)	3	(75)	1	(25)
		Total	61		57	(93)	4	(7)
Wilks' Lambda:	0.87							
Chi-Squared:	8.17							
Significance Level:	0.01							
Canonical Correlation:	0.36							

Table B2.6 Fifth percentile scores for personnel passing Low-High Crawl by sex and age level.

Variables	Women < 35	Women $\geq$ 35	Men $\geq$ 35
EXPRES			
Maximum Grip	65.3	43.2	72.7
VO_2 Max	33.1[abcd]	29.7[abd]	31.1[c]
Situps	15.4[b]	11.8[b]	16.6[abcd]
Pushups	0.75[abc]	-3.0[ad]	5.5
Queen's			
ILM	23.1[abcd]	17.6[a]	36.1
Endurance Grip	10.3	-2.9[b]	54.6
Flexed Arm Hang	1.2[abcd]	-9.15[abcd]	4.4[cd]

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

years in Table B2.6 were in close agreement with the previous suggested standards however the value for younger women was very high in comparison to previous data. However, the minimum grip requirement for women <35 years proved unrealistically high: 65.3 kg a value equivalent to the 90th %ile according to Canadian norms for females in this age bracket (Reid & Thomson, 1986: p. 129). In Phase II, a minimum of 42.5 kg was determined on this task, a score much more compatible with the concept of minimum fitness (i.e., a 42.5kg minimum is <25th %ile by Canadian norms). None of these scores were related to task performance for any group. Hence the values in Table B2.6 merely represent the description of women who passed the task. related to task performance

2. The 5th percentile of passers for women <35 and men ≥35 years for VO_2max and sit-ups were both comparable to the previous standards for these groups and compatible with Canadian norms (i.e., <30th %ile, according to sex and age grouping; Reid & Thomson, 1985: pp. 126 & 142). Similarly, the minimum fitness values for women ≥35 years for VO_2 Max (29.7 ml/kg/min) and number of sit-ups (11.8) appeared reasonable minimums, particularly by comparison with national norms (i.e., again <30th %ile).

3. By contrast, the determinations for pushups for both groups of women were unreasonably low, and particularly so in light of the demonstrated physical strength and performance abilities (i.e., setting several task time records) possessed by the group of younger women in the present study: a less-than-one pushup requirement for women <35 years; a negative pushup for women ≥35 years result from a z-score distribution transformation. As discussed at length in Section A, the requirement that full pushups be performed by the

females participating in Phase III, as opposed to pushups-from-the-knees performed in Phases I and II, was felt responsible for these spurious results.

4. Calculation of minimum pushups for men $\geq$35 years also resulted in a low value, particularly in comparison to both the established minimum for this subject group (i.e., 14 pushups, established by Phase II) and by Canadian normative standards (i.e., a 5.5 minimum is well below the 10th percentile for this age group). On the other hand, as a group these 61 subjects scored particularly high on their EXPRES pushups score (i.e., 27.1$\pm$13.5 pushups, above the 75th %ile according to Canadian norms).

Table B2.6 also summarizes the statistical findings of the earlier analyses carried out on subjects' low high crawl data throughout this section (see Table footnotes) to indicate the relative importance of fitness variables to each of the groups in terms of evaluating task performance. Examining across the rows, note that no EXPRES and laboratory test item was identified as a significant variable in every instance, although subjects' VO_2 Max and flexed arm hang-time appeared an unusually high number of times through the analyses. On the other hand, maximum grip scores proved to be of little value in predicting subject performance on this task. In Table B2.7 the fitness scores of the subjects passing the low high crawl are compared to failing subjects' scores: the individual averages for 'passers' versus 'failers' on each EXPRES and laboratory test are compared by Student t-test (with significance accepted at the 0.01 level in this instance only). Of the 21 comparisons, 10 proved to be significantly different; more importantly, in every case the 'passers' fitness scores were the higher value, and this trend is also evident in every comparison. It should be noted, however, that of the 11 comparisons found to be non-significant ($p>0.01$), 6 of these differences

Table B2.7 EXPRES and Laboratory Fitness Scores of passers vs failers on the Low-High Crawl task.

Variable		Women < 35 Pass		Women < 35 Fail	Women ≥ 35 Pass		Women ≥ 35 Fail	Men ≥ 35 Pass		Men ≥ 35 Fail
EXPRES										
Max Grip	M	74.2		72.0	60.6		53.8	109.6		109.5
	SD	(10.9)		(11.6)	(10.6)		(12.7)	(22.5)		(13.5)
VO_2 Max	M	38.7	*	34.8	34.3	*	2.8	41.1		36.5
	SD	(3.4)		(2.6)	(31.0)		(3.4)	(6.1)		2.2
Situp	M	36.2	*	28.6	26.7	*	18.5	32.7	*	18.8
	SD	(12.7)		(9.3)	9.0		8.6	(9.7)		(1.3)
Pushup	M	23.4	*	12.5	9.3		8.6	27.9		19.3
	SD	(13.8)		(5.8)	7.5		11.5	(13.7)		(5.9)
Queen's										
ILM	M	32.3	*	28.9	27.4		24.7	52.8		47.5
	SD	5.6		4.5	6.0		2.8	(10.2)		(6.5)
Endurance Grip	M	88.2		75.5	105.4	*	50.9	235.3		215.3
	SD	(47.5)		(44.6)	66.0		23.5	(110.1)		(53.6)
Flexed Arm Hang	M	28.8	*	9.4	14.9	*	2.2	31.6		17.3
	SD	(16.8)		(10.2)	14.7		3.1	(16.6)		(11.2)

Note. * Reliable difference ($p < .01$) between passing and failing group means.

were marginal (i.e., almost numerically equal).

B2.4.7 Impact of Passing and Failing

Using the minimum scores suggested for each group, Table B2.8 was derived to examine the impact of correct classification of task performance based on passing or failing EXPRES composition standard from Section A Table A14. Overall, 64% would have been correctly classified as passing and 13.3% as failing the task based on their EXPRES scores. A total of 21.3% would have been incorrectly classified by performance on this task. This level of incorrect classification was a result of fitness parameters explaining only 20% to 50% of the variance in the data. In other words, for the single task of low-high crawl, a total of 21.3% of the subjects would have been incorrectly classified.

B2.5 Interpretation

Several notable comparisons were found between our two previous studies, Phase I and II, and the present phase. Foremost, comparing Phase II and III low high crawl results for women <35 years and men ≥35 years (i.e., the two repeat groups in the present phase), the completion times and split-times of the respective groups were very close, with several times being almost identical (Stevenson et al, 1986). Thus, relocation of this task indoors and use of a rubberized runway replacing an outdoor grass surface did not appear to influence results unduly; and from the investigators' vantage the present format incorporated several convenience and logistical advantages. Second, subjects' crawl times through the low course (30 m) were again, as in Phase II, substantially slower than over the high course (45 m). In the case of the women ≥35 years the low course took twice as long to complete. (Note: in Phase I, without the overhead barriers in place low crawl times had been substantially faster; Stevenson et al, 1985.) As concluded in Phase II

Table B2.8 Impact of Fitness Standards on Classification by Pass/Fail Status for Low-High Crawl Task.

Fitness Test Performance	Low High-Crawl Task Performance			
	Correctly Classified (no)	Correctly Classified (%)	Incorrectly Classified (no)	Incorrectly Classified (%)
Pass EXPRES	96	64.9	19	12.8
Fail (1 or more)	20	13.5	13	8.8
Total	116	78.9	32	21.6

(Stevenson et al., 1986), this finding again reinforced the necessity of placing the barriers over the low course forcing subjects to perform the more technically difficult leopard crawl correctly. Third, as concluded in both Phase I and II (Stevenson et al., 1985 & 1986), again a pass/fail criterion for this task of 90 seconds would have proven unrealistic for these groups of subjects as a minimum standard: 43 (of 62) men $\geq$35 years, 55 (of 59) women <35 years and 27 (of 28) women $\geq$35years, in all 87% of the subjects would have failed, in fact the equivalent percentages of subjects failing as reported in our two earlier studies. In this study, 46% of younger women failed the task based on a 134 second standard. With the restraint adjustment, 71% of older women passed and 93% of older men passed the criteria. In total 36 or 26% of the subjects failed the task criteria. Fourth, in the present study more overlap between the men and the two women's groups was observed (than in either Phase I or II), both in their total times for completion of the task and various split-times through the course. However, the reason for this finding was believed due to the particular male population of Phase III: always in the past a majority of males have been <35 years of age, therefore, not paced through the low high crawl course (as subjects $\geq$35 years must be); in the present study 100% of the males were $\geq$35 years and forced to retard their pace in many instances, as did many of the women $\geq$35 years. Fifth, based upon the correlation analyses summarized in Tables B2.2a -.2c, total time for completion of the low high crawl was (again) determined to provide the optimal measure for evaluating subjects' performances because of its simplicity and relationship to physical fitness (Stevenson et al, 1986): that is, the other analyses comparing the split-times through the course versus the individual fitness variables did not produce consistently higher r-values, therefore little would be gained by incorporating any of these into the task's evaluation format.

In the present study the univariant analyses revealed similar trends to the ones observed in both earlier studies (Stevenson et al., 1985 & 1986): low r-values have been consistently found between fitness scores and task performance, with only a sparse number proving significant (in Phase II only 39 of 360 r-values and in the present study 29 of 150, $p<0.001$). On the other hand, as seen in both earlier studies, the vast majority of coefficients have always appeared as negatives. In the present study 62 of the 63 fitness-related r-values were negative, indicating that there was indeed an underlying relationship between fitness as measured by EXPRES and performance of the low high crawl. However, the relatively few correlations that have provided significance have seldom revealed any definitive patterns, except for a number of significant r-values the flexed arm hang. This finding was surprising in itself for several reasons. Such a strong relationship had not been observed in the past: in Phase II only 2 of 24 coefficients relating flexed arm hang-time and low high times proved significant (Stevenson et al, 1986), while in Phase I the flexed arm hang was found unrelated to crawl performance (Stevenson et al., 1985). Further, in the present study, in many instances there was only minimal dispersion of subjects' scores on this particular laboratory fitness test, for example women ≥35 years, the group recording the highest significant r-values (see Tables B2.2a -.2c): 8 (of the 28) subjects in this group could not perform this laboratory test (with their score being recorded as 0:00 seconds), while 19 subjects recorded scores ≤5 seconds duration hang-time (see Appendix E).

Through the three Phases of development of a minimum standard, generally, our multivariant analyses have not improved the predictive value of EXPRES or the laboratory tests in evaluating subject performance on the low high crawl task. For example, compare the distinct sets of performance predictors identified through stepwise regression analysis over the various Phases. In

Phase II, for men ≥35 years, no reliable variables were found, whereas for the other two subject groups, both men and women <35 years, flexed arm hang, and sit-ups and flexed arm hang (respectively) were found reliable predictors but accounted for only 23% and 38% of the variance in these groups' low high crawl times. In Phase I, where the majority of subjects was also <35 years in the two subject groups, for the males only VO_2 Max was found to be a reliable predictor while females' age provided the only reliable variable in their prediction equation; however, the latter variable was obviously unrelated to fitness while, by itself, VO_2 Max accounted for only 16% of the variance in total crawl time for the males. In the present study, by contrast, at least two fitness variables appeared in each group's regression analysis (and for women <35 years, 3 significant variables were found). However, VO_2 Max was the only repeat variable (i.e., also found in Phase I or II). And only for the women ≥35 years, the 'new' group in Phase III being studied intensely for the first time, was a major portion of the variance accounted for; in the two 'repeater' groups in Phase III, once again, only a modest amount of the variance in their crawl times was explained. On the other hand, blocked regression analyses have tended to confirm the fact that the most important fitness component in performance of the low high crawl was strength-endurance, with specific combinations of fitness prerequisites being required according to the subject group. In Phase II, for each of the subject groups the strength-endurance component accounted for the greatest changes in R^2 (range: 0.20 to 0.40) and this was confirmed by the present data with the strength-endurance component again accounting for the largest changes in R^2 (range: 0.20 to 0.30); however, only for the women <35 years in the present study was the regression equation found to be significant (at the accepted $p<0.001$).

In the discriminant analysis certain variables were repeated as canonical coefficients, however the explanation of data variance remained low (Table

B2.5). Anywhere from 7% to 20% of the subgroups would have been classified incorrectly if these standards were used. Hence it can be safely stated that EXPRES and additional laboratory tests cannot explain the variance in score past 50%, nor can these tests be used as an accurate discriminator between passing and failing the task.

B2.6 Conclusions

EXPRES was not an adequate predictor or discriminator of performance success on the low high crawl task. The additional laboratory tests improved performance prediction only minimally, with the possible exception of subjects' flexed arm hang-time. However, the reliability of this latter variable was questionable, as discussed in the last section. Therefore, the conclusions to be drawn concerning task performance were limited by the lack of definitive statistical relationships between fitness and performance.

1. These data suggested that a relationship existed between one's fitness (as measured by EXPRES and our laboratory tests) and performance of the low high crawl as 35% to 64% of the variance in data were determined. However as with previous studies, general fitness measures cannot predict performance on the low-high crawl task.
2. As concluded in both Phases I and II, strength-endurance was the most important fitness component in performance of this task and, according to present data, flexed arm hang the most significantly related strength-endurance test.
3. Because of extenuating circumstances (discussed in Section B2.5) specific minimum values for push-ups for women should be disregarded, in creation of a standard.
4. Only the variables which related to task performance should be a part of the criteria for minimum standards. These variables were

oxygen consumption and sit-ups for all three groups.

5. The scores in Table B2.6 reasonably represent these subjects who were able to pass the low-high crawl task. As each group differed in minimal requirements, the standards reflect the passers for each group.

More generally, the investigators recommend that:

6. The low high crawl task be moved indoors and the present procedures be considered as the standardized task protocol with the pass criteria for younger subjects being 130 seconds and 172 seconds for older subjects.

7. That standards for full pushups for women undergo additional assessment prior to establishing minimal criteria. A follow-up study to clarify the relationship between this exercise and military task performance by CF female personnel is necessary.

B2.7 Recommendations

The low-high crawl task was selected as a test item as it was considered to be one of the most physically demanding tasks within the designated list of Seven Common Tasks for CF Personnel (excluding NBCW clothing which would raise the physiological requirement an undetermined amount). The task criterion was predetermined to be time for task completion. From a relaistic standpoint, safety (quietness) might also have been coOnsidered a relevant factor.

As this task was very novel for some men and all women, it is important to recommend that:

1. Subjects should receive more extensive training prior to execution of this task.

SECTION B3

LAND STRETCHER EVACUATION TASK ANALYSIS

SECTION B3

LAND STRETCHER EVACUATION TASK ANALYSIS

B3.1 Introduction

Casualty evacuation overland was simulated by carrying the equivalent of an 80 kilogram person by stretcher a distance of one kilometre. As initially tasked by the CF, a significant modification in protocol was implemented during Phase II, that of changing the land stretcher carry from a two-person to a one-person task; the rationale for this major change was detailed in our final report (Stevenson et al., 1986: pp.100-103). However, the performance criterion initially established by the CF, 20 minutes for completion of the evacuation, was retained because in both Phase I and II 71% and 75%, respectively, of all subjects achieved this time. As well during Phase II, a number of derived variables (i.e., split times, drop-off indices, etc.) were calculated; however, only in a few instances did these variables prove marginally superior predictors of performance and, for the most part, were inferior to total time, the simplest and most straightforward quantitative performance variable to record (Stevenson et al., 1986).

B3.2 Task Rationale

To complete the land evacuation twenty minutes of heavy exercise must be performed (Astrand and Rodahl, 1977). Data from Phase I underscored this fact with subjects' heart rates, regardless of age or gender, on average reaching 169 ± 15 beats/minute (Stevenson et al., 1985). During Phase II, of the 90 subjects ≥35 years wearing heart rate monitors over 80% had to be paced or stopped at some point during the evacuation task to allow their heart rate to drop below 90% (of each individual's predicted maximal rate). The most acute problem observed with load carrying over a prolonged period is local muscle fatigue of the hand and wrist flexors (Lind & McNicol, 1980; Kearney & Stull, 1981; Gordon et al., 1983). In Phase I, the number of stops (i.e., a forced set-down of the stretcher by the subject) was observed to be related to the strength-endurance of the weaker wrist. But unfortunately, neither the number of set-downs nor grip strengths provided satisfactory prediction of performance, while grip endurance proved to be only minimally correlated (Stevenson et al., 1985). In Phase II, combined grip strength provided the most important EXPRES variable in performance of the land stretcher carry, but, again this variable could not provide the statistical basis for prediction (Stevenson et al., 1986). Finally, studies have concluded that the time to fatigue varies with the weight of the load being carried (Evans et al., 1983; Gordon et al., 1983), and carrying a load one-half the body weight elicits a physiological response of approximately 75% of a subject's maximal aerobic capacity (Gordon et al., 1983). In the earlier phases of the project, for the lighter subjects the 80 kg stretcher loading often exceeded this value, and the faster these subjects attempted to move the proportionately greater amount of their aerobic capacity was required (Soule et al., 1978).

For Phase II several protocol modifications were instituted to improve test objectivity and subject assessment on the land stretcher task. Most significantly, a set of wheels was affixed below the rear end of the land stretcher making this evacuation a one-person task and permitting individual assessment (i.e., prior to this modification a second person carrying 'the other end' of the stretcher influenced subject scores). This modification permitted greater objectivity and individual assessment; as well, a further protocol alteration involved use of an indoor circuit (i.e., in earlier phases the land stretcher carry was conducted on quarter-mile running tracks outside). This modification provided two advantages: first, although smaller in size, which seemed little disadvantage, the flooring of the indoor circuit (i.e., the arena cement) provided a superior and uniform surface for the task;

second, indoors testing was independent of inclement weather conditions outside which had both disrupted test scheduling in earlier phases as well as altering the tracks' cinder surfaces day to day. In addition, as the correlation between 750m and a 1km time was p=.96, the shorter course was developed for expediency and reduced subject discomfort.

B3.3 Task Protocol

This task simulated the casualty evacuation of an 80 kg soldier by land stretcher a distance of 1 km as quickly and safely as possible. The task itself was modified to create a single-person task; the structural changes to the stretcher which permitted this involved the addition of wheels beneath the rear end of the stretcher. Weights were securely positioned 25 cm from the front end of the stretcher to simulate for that person the equivalent of the 80 kg wounded soldier being evacuated. The height of the stretcher bed was also adjustable according to the height of the subject and arm length so that the mass remained horizontal to the ground.

The stretcher carry was performed indoors around a 125 m course set out around the arena floor at Queen's University, with 6 laps to complete .75 km. A distance of 750m was chosen because in Phase II results, the correction between 750 m and 1000 m was r=.97 for women and r=.95 for men. Distance markers were positioned around the track both to indicate to subjects their distance traveled at any given point as well as to allow laboratory personnel to accurately record split-times and set-down distances. The subject started positioned at the front of the stretcher pulling in ricksha fashion and walked briskly or jogged at a self-determined pace; as well, the frequency and duration of set-downs were left to the discretion of the subject.

The variables recorded were split-times (in seconds) at completion of 125m, 250m, 375m, 500m, 625 m and 750m. Although not necessary total time was calculated to complete the kilometre.

B3.4 Results

B3.4.1 Descriptive Results

In Table B3.1, total times for completion of the land evacuation task and split-times are presented. On average, men ≥35 years completed the task in a faster time (just under 10±3 minutes) than female subjects. This trend was also reflected in their split-times throughout the 750m stretcher carry. Women <35 years completed the task in 12.9±3.8 minutes, the women ≥35 years completed in 16±5 minutes, with both groups requiring a greater number of set-downs during their carry when compared to men ≥35 years. On the other hand, as noted in earlier Phases of the study there was considerable overlap between a number of the faster females in both age groups and one-third of the slower males.

B3.4.2 Simple Correlations

Tables B3.2a B3.2b and B3.2c present correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to their performance times, in Table B3.2a total time over the 750 km, and their time splits in Table B3.2b and B3.2c. As seen from Table B3.2a, for all subjects, only seven (of 30) r-values were found to be significant at the (accepted) 0.001 level of confidence, while many approached zero; however, most of the relationships were in the expected direction (i.e., negative, the higher one's test scores, the less total time taken). Similariliy, in Table B3.2b there appeared little relationship between split times and fitness parameters; while a few more r-values were found to be significant (14 of 150 coefficients) no consistent pattern was observed.

Table B3.1 Summary of Land Evacuation Task Performance Scores of the Sample by Age Group and Sex.

	Split Times (s) 0 to 125 m	125 to 250 m	250 to 375 m	375 to 500 m	500 to 625 m	Total Time to 750 m
<u>omen < 35 years</u>						
n= 58						
Mean	87.0	200.3	338.5	480.7	632.6	771.6
SD	21.9	53.4	93.0	138.0	189.5	226.4
(min-max)	(54.0-164.3)	(130-402)	(208-662)	(288-1003)	(369-1380)	(445-1656)
<u>Women ≥ 35 years</u>						
= 28						
Mean	117.2	266.5	430.6	593.6	771.8	960.3
SD	39.5	90.9	144.3	182.7	226.9	297.6
min-max)	(60.6-219)	(139.2-477)	(206.1-829)	(285.8-1101)	(384.6-1329)	(470.5-160
<u>en ≥ 35 years</u>						
n= 62						
Mean	78.5	166.8	264.2	367.5	477.9	582.9
SD	16.8	38.0	69.2	101.6	133.0	167.5
(min-max)	(41-134.5)	(65-261.9)	(132-473)	(178-680.8)	(234-889.2)	(288-1084)

Table B3.2a Correlations Between Land Evacuation performance measures and fitness parameters by sex and age level: Total time.

	Women <35	Women ≥35	Men ≥35
Anthropometry			
Age	.37	-.25	.30
Height	-.38	-.49	-.21
Weight	-.08	-.06	-.01
Muscular Strength and Endurance			
Situp	-.45*	-.32	-.46*
Pushup	-.37	-.10	-.41
Combined Grip	-.38	-.64*	.01
Endurance Grip	-.32	-.64*	-.47*
Flexed Arm Hang	-.45	-.49	-.36
Maximum ILM to Full Extension	-.52*	-.34	-.34
Aerobic Capacity			
Step test	-.40	-.33	-.52*

* $p<.001$.

Table B3.2b Correlations Between Land Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Split Times.

	0-125 m			125-250 m			250-375 m		
	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35
Anthropometry									
Age	.29	-.28	.29	.33	-.19	.24	.28	-.22	.25
Height	-.31	-.27	-.08	-.35	-.33	-.20	-.36	-.36	-.18
Weight	-.03	-.09	.13	-.07	-.06	.04	-.10	-.05	-.01
Muscular Strength and Endurance									
Situp	-.44	-.05	-.42	-.35	-.22	-.51*	-.44	-.25	-.46*
Pushup	-.27	-.15	-.37	-.29	-.20	-.42	-.33	-.23	-.41
Combined Grip	-.47*	-.34	-.05	-.40	-.45	.004	-.31	-.49	.01
Endurance Grip	-.24	-.41	-.38	-.21	-.55	-.40	-.27	-.58	-.44*
Flexed Arm Hang	-.32	-.33	-.35	-.33	-.41	-.37	-.35	-.41	-.33
Maximum ILM to Full Extension	-.30	-.23	-.32	-.42	-.33	-.35	-.49*	-.29	-.33
Aerobic Capacity									
Step test	-.32	-.38	-.55*	-.41	-.39	-.56*	-.27	-.38	-.55*

* $p<.001$.

Table B3.2c Correlations Between Land Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Split Times

	375-500 m			500-625 m		
	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35
<u>Anthropometry</u>						
Age	.36	-.26	.25	.37	-.30	.28
Height	-.39	-.41	-.20	-.39	-.40	-.21
Weight	-.10	.01	-.02	-.09	.01	-.02
<u>Muscular Strength and Endurance</u>						
Situp	-.44	-.33	-.46*	-.42	-.36	-.48
Pushup	-.33	-.22	-.43	-.33	-.25	-.43
Combined Grip	-.34	-.53	.03	-.34	-.56	.02
Endurance Grip	-.32	-.61	-.46*	-.34	-.65*	-.45*
Flexed Arm Hang	-.40	-.45	-.35	-.41	-.51	-.34
Maximum ILM to Full Extension	-.49*	-.28	-.35	-.51*	-.32	-.37
<u>Aerobic Capacity</u>						
Step test	-.37	-.36	-.48*	-.37	-.38	-.51

* $p<.001$.

B3.4.3 Stepwise Regressions

Results of analyses regressing total time on EXPRES and laboratory test variables are presented in Table B3.3. For women ≥35 years, their maximum grip strength and VO_2 Max were accepted in the analysis, accounting for 57% of the variance in total time. By contrast, for women <35 years EXPRES sit-ups, their maximal ILM lift and VO_2 Max were accepted, accounting for 43% of the variance, while for men ≥ 35 years VO_2 Max and endurance grip reliably predicted their land evacuation performance but accounted for only 31% of the variance in total time.

In Table B3.4, blocked regression analyses are presented, with total time regressed on fitness parameters blocked according to the major fitness components studied (i.e., muscle strength-endurance and aerobic capacity). None of these fitness components provided reliable relationships (at the accepted 0.001 level) either for the women or men ≥35 years of age. On the other hand, for women <35 years the greatest change in R^2 (0.36) was accounted for by their strength-endurance component which evidenced substantial relationship ($p<.001$) with total time.

B3.4.4 Criteria for Passing the Task

The land evacuation task had not been changed significantly over the course of three contracts in that the load (80kg) and target times (20 minutes) remained the same. Both in Phase I and II, 71% and 75% respectively were able to pass the task criteria. As the correlation between 750m and 1km were r=.97 and .95 for women and men respectively, the land stretcher task was shortened to 750m. (This correlation was advantageous as the last quarter of the task was an exercise in pain tolerance rather than fitness.) The target time for younger subjects was 15 min. The older subjects were given a 32% adjustment based on the heart rate restriction substudy and a matched sample of older men and women. This gave a target time of 19.8 min for subjects ≥35

Table B3.3 Stepwise Regression of Land Evacuation total time on fitness parameters by sex and age level.

Variables in Equation	B	SE B	Mult. R.	R^2	F	p
Women < 35 years						
Constant	1886.36	235.89				
Situps	-5.74	1.83	.49	.24	16.54	.001
ILM	-12.14	4.02	.58	.34	13.25	.001
VO_2 Max	-15.59	5.62	.66	.43	12.55	.001
Women ≥ 35 years						
Constant	2923.68	451.39				
Maximum Grip	-16.55	3.82	.66	.44	16.42	.001
VO_2 Max	-29.81	11.98	.75	.57	13.22	.001
Men ≥ 35 years						
Constant	1124.10	122.06				
VO_2 Max	-10.71	2.96	.46	.21	14.72	.001
Endurance Grip	-.48	.17	.56	.31	12.26	.001

Table B3.4 Land Stretcher Evacuation total time regressed on EXPRES and other laboratory tests blocked for fitness components.

Block	R^2 Eqn.	F Eqn.	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	.24	4.90	.01	.24	4.90	.01
Strength and Endurance	.60	6.84	.001	.36	6.19	.001
Aerobic Capacity	.64	7.20	.001	.04	4.77	.05
Women ≥ 35 years						
Anthropometric	.43	4.31	.05	.43	4.31	.05
Strength and Endurance	.74	3.51	.05	.31	2.20	NS
Aerobic Capacity	.84	5.24	.01	.10	6.09	.05
Men ≥ 35 years						
Anthropometric	.22	4.84	.01	.22	4.84	.01
Strength and Endurance	.38	3.26	.01	.17	2.16	NS
Aerobic Capacity	.41	3.22	.01	.03	2.12	NS

years.

B3.4.5 Discriminant Analysis

Results of discriminant function analysis (conducted independently for groups) using a stepwise procedure in which both EXPRES and laboratory variables were tested are presented in Table B3.5. The functions obtained for each group of subjects correctly classified a high number of subjects, however, in each case the discriminating variables were unique (to each group) while the functions themselves were non-significant at the 0.001 level of confidence; that is, the variables identified could not reliably discriminate between 'passers' and 'failers' for each of the groups. For women <35 years, EXPRES sit-ups, their ILM lift and VO_2 Max were identified as discriminating variables, with the resultant function correctly classifying 80% of the cases. The discriminant function for women $\geq$35 was comprised of endurance grip and their ILM lift, and this function correctly classified 79% of these women. By comparison, the three variables which appeared in the discriminating function for men $\geq$35 years were VO_2 Max, endurance grip and sit-ups which correctly classified 97% of subjects in this instance.

B3.4.6 Fifth Percentile of Passing Group

In Table B3.6, the PASSERS within the individual groups (i.e., only the subjects bettering the pass criterion of 15 minutes or 19.8 minutes for young and older subjects respectively) are profiled according to <u>minimum</u> EXPRES and laboratory scores based on the land stretcher task only. These values incorporated an almost identical subset of minimum EXPRES values as determined for the low high crawl in the preceding section (see B2.5) with a few notable exceptions.

1. Minimum sit-ups were comparable to values calculated for the low high crawl 'passers' but, once again, slightly lower than our Phase

Table B3.5 Discriminant analysis and classification results by EXPRES and Queen's variables in groups defined by Land Evacuation pass fail status.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	Performance %	Predicted Performance Correctly Classified n	Correctly Classified %	Incorectly Classified n	Incorectly Classified %
Women < 35 years								
Situps	0.54	Pass	44	(79)	41	(93)	3	(7)
ILM	0.59	Fail	12	(21)	4	(33)	8	(67)
VO_2 Max	0.43							
		Total	56		45	(80)	11	(20)
Wilks' Lambda:	0.81							
Chi-Squared:	10.87							
Significance Level:	0.05							
Canonical Correlation:	0.43							
Women ≥ 35 years								
Endurance Grip	0.80	Pass	16	(57)	15	(94)	1	(6)
ILM	0.44	Fail	12	(43)	7	(58)	5	(42)
		Total	28		22	(79)	6	(21)
Wilks' Lambda:	0.63							
Chi-Squared:	11.47							
Significance Level:	0.01							
Canonical Correlation:	0.61							
Men ≥ 35 years								
VO_2 Max	1.05	Pass	58	(97)	56	(97)	2	(3)
Endurance Grip	0.50	Fail	2	(3)	2	(100)	0	(0)
Situps	-0.54							
		Total	60		58	(97)	2	(3)
Wilks' Lambda:	0.87							
Chi-Squared:	7.97							
Significance Level:	0.05							
Canonical Correlation:	0.36							

Table B3.6 Fifth percentile scores for personnel passing Land Evacuation by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	57.7	17.9[bcd]	72.9
VO_2 Max	31.2[ad]	28.1[d]	31.2[abcd]
Situps	15.2[abcd]	9.9	15.4[ac]
Pushups	-2.11	-2.26	5.1
Queen's			
ILM	22.9[abcd]	18.3[ab]	35.9
Endurance Grip	15.8	9.8[abc]	58.3[acd]
Flexed Arm Hang	-6.9[b]	-7.8[b]	2.8

Note a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

II values for the women <35 and men $\geq$35 years (Stevenson et al., 1986). For younger women this was a result of a skewed sample and for older men a result of combining older males and females to determine a passing score.

2. The minimum values for VO_2 Max for the two groups of women were slightly elevated compared to the proposed Phase II value for women <35 years, while for men $\geq$35 years was in close agreement with their previously suggested minimum (Stevenson et al., 1986).

3. On the other hand, subjects' stretcher carry data provided some unreasonable values, very similar to the ones calculated from subjects' low high crawl results:

   i) Minimum pushups for both groups of women produced <u>negative</u> Phase values; again, the drastic change in pushup technique for the present study was felt responsible for this spurious finding. (See Section B2.4.6 for detailed explanation.)

   ii) Minimum pushups for men $\geq$35 years was surprisingly low considering their relatively high scoring on EXPRES (i.e., as a group, 27.1$\pm$13.5 pushups, well above the 75th %ile on Canadian norms; Reid & Thomson, 1985: p.127).

   iii) Minimums for grip strength again produced mixed values, the men $\geq$35 closely approximating the proposed Phase II (Stevenson et al., 1986), with the minimum for women <35 again quite high (i.e., at the 65th %ile according to national norms; Reid & Thomson, 1985: p.129), and Phase II for women $\geq$35 years again unusually low.

Table B3.6 also summarizes the statistical findings of the earlier analyses carried out on subjects' stretcher carry data throughout this section (see Table footnotes) to indicate the relative importance of fitness variables to each of the groups in terms of evaluating task performance. Compared to identical analyses carried out using subjects' low high crawl data (see Table B2.6), note that the EXPRES and laboratory test variables identified as playing an important role were neither consistent across groups nor within groups. In Table B3.7, the fitness scores of the subjects passing and failing the land stretcher carry were analyzed: individual averages for 'passers' versus 'failers' on each EXPRES and laboratory test are compared (by Student t-test, with significance accepted at the 0.01 level in this instance only). Of the 21 comparisons only 8 proved to be significantly different, however in every case the trend was identical with the 'passers' fitness scores proving the higher value. And a similar trend could in fact be observed examining all 21 comparisons: in <u>every</u> instance the mean score of the passing subgroup was higher. It should be noted, however, that of the 13 differences found to be non-significant 5 of these differences were marginal (i.e., almost numerically equivalent); on the other hand, several comparisons provided huge differences, the most striking being endurance grip (mean time differences were +29.0 sec., +69.9 sec., and +146.2 sec. for 'passers' over 'failers' for women <35, women $\geq$35, and men $\geq$35 years, respectively).

B3.4.7 Impact of Passing and Failing

After all tasks had been appraised and standards suggested based on reliable relationships between tasks and tests, (Table A14) the impact of these standards were compared to the low high crawl performance in Table 3.8. In this task 18% of the subjects would have been incorrectly classified based on these proposed standards. The number of individuals who would have failed EXPRES but passed the land evacuation task was 11%, a value higher than the anticipated impact of 5% of passers. As all tasks were summated to examine the impact in Section A, the number of false classifications may have been reduced.

Table B3.7 EXPRES and laboratory fitness scores of passers vs failers on Land Evacuation task.

Variable		Women < 35 Pass		Women < 35 Fail	Women ≥ 35 Pass		Women ≥ 35 Fail	Men ≥ 35 Pass		Men ≥ 35 Fail
EXPRES										
Max Grip	M	74.1		70.0	63.5	*	52.2	109.5		22.3
	SD	10.0		14.1	9.5		10.9	(104.5)		(4.9)
VO_2 Max	M	37.3		35.3	33.9		32.6	41.0	*	31.4
	SD	(3.7)		(2.9)	3.5		3.0	(6.0)		(0.1)
Situp	M	34.0	*	25.2	26.8		21.0	31.9		27.5
	SD	(11.5)		(8.8)	10.3		7.5	(10.1)		(3.5)
Pushup	M	19.4		14.3	9.9		8.1	27.5		16.0
	SD	(13.1)		(7.9)	8.0		9.6	(13.7)		(8.5)
Queen's										
1LM	M	31.5	*	27.3	28.6	*	24.0	52.6		50.0
	SD	5.2		5.3	6.3		2.0	(10.1)		(0.0)
Endurance Grip	M	89.0		60.0	119.8	*	49.9	235.2		89.0
	SD	(44.6)		(49.4)	67.1		15.9	(107.9)		(42.4)
Flexed Arm Hang	M	21.9	*	10.3	16.4	*	4.5	30.5		22.8
	SD	17.5		8.7	14.7		8.8	(16.9)		(16.2)

Note. * Reliable difference ($p<.01$) between passing and failing group means.

Table B3.8 Impact of fitness standards on classification by pass/fail status for Land Evacuation task.

Fitness Test Performance	Land Stretcher Evacuation Task Performance			
	Correctly Classified (no)	(%)	Incorrectly Classified (no)	(%)
Pass EXPRES	103	71.0	10	7.0
Fail (1 or more)	16	11.0	16	11.0
Total	119	82.0	26	18.0

B3.5 Interpretation

In the Phase II study both groups of older subjects (the men and women ≥35 years) completed the 750 m evacuation in less time on average than their respective counterparts <35 years (Stevenson et al., 1986). While this was not the case in the present phase there were several notable comparisons with our earlier phases. First, both groups of women in the present study completed the land stretcher task in record times (for female subjects, compared to Phase I and II results). Second, all times were on average faster for the present groups of subjects, with the men ≥35 years achieving the fastest time for completion of their 750m evacuation of any group of subjects studied. Third, by contrast, one fact has been consistently observed throughout the three phases: independent of the subjects' gender, age, or testing locale, split-times have remained proportionate: that is, slower total times invariably have resulted in longer split-times and, oppositely, faster completion times have reflected shorter splits. Fourth, this latter finding, in turn, has substantiated the most important strategy for completing the land evacuation task, specifically that subjects should stay within their capacities throughout the carry, proceeding at a constant pace rather than attempting to speed up during any particular phase through the carry. Transferred to live combat situations, this would also appear to be the prudent approach for instructing Forces personnel.

In the present study the univariant analyses revealed similar trends to ones observed in both of our earlier phases: foremost, low r-values have been consistently found between fitness scores and task performance, with only a sparse number proving significant (in Phase II only 16 of 189 r-values and in the present study 21 of 180, $p<.001$). And these few correlations have seldom revealed any definite patterns. On the other hand, the vast majority of r-values have always appeared as negatives indicating that there was indeed an underlying relationship between fitness (as measure by EXPRES) and performance on the land stretcher carry. Further, it was also interesting to note that, as in Phase II, the highest negative r-values were found: for men ≥35 years, between total time and their aerobic capacity (as determined by EXPRES step test); for women (but only for the ≥35 group in the present study) between total time and their grip scores (i.e., the r-values for both their combined and endurance grips was -0.64, $p<.001$). As the mass carried was on the average 61.6% of the fbody weight of women, then grip strength would be an obvious factor. For men grip strength would be of less importance in task completion as the mass was 49.8% of body weight. Finally, our additional univariant analyses, first attempted in Phase II correlating subjects' split-times through the land stretcher carry with individual fitness scores, again did not result in higher or more consistent r-values, verifying our earlier conclusions regarding this analytical means of evaluating subject performance: total time (for completion of the land evacuation) was in fact the single, best measure for evaluating subjects' performances when using time as the single assessment of performance. (Stevenson et al., 1986).

Through the three phases of MPFS, in general our multivariant analyses have improved the predictive value of EXPRES in evaluating task performance, but seldom has any consistent pattern of multi variables been identified. For example, compare the unique set of performance predictors identified in our stepwise regression analysis for females <35 years: in Phase I (with 31 of the 33 women in the group <35 years) their height combined with EXPRES pushups provided significance; in Phase II for that group of women <35 years only their arm power appeared in the regression equation; and in the present study for the women <35 years a combination of three different variables (i.e., sit-ups, ILM, VO_2 Max) were found to be significant. As well, through our three Phases, and for both men and women, any specific set of significant multi variables has never accounted for more than 60% of the variance in total time for the land stretcher carry. In the present study, only for the women ≥35 years was a substantial portion of the variance in total time accounted for (i.e., 57%) by the variables identified in their regression equation; for the other two subject groups R^2 values were substantially lower, 0.43 and 0.31 for women <35 and the men ≥35 years, respectively. In comparison to our two earlier studies, stepwise discriminant analyses testing EXPRES and laboratory variables independently by groups were able to correctly predict both a higher percentage of subjects passing the land stretcher task (79% - 97%, according to the respective groupings), while significantly reducing their numbers incorrectly classified (i.e., only 2 of 60 males ≥35 years incorrectly classified, and 17 of a total of 84 female subjects). However, this apparent improved ability in Phase III to discriminate may be artifactual: a much smaller number of subjects - and women in particular in the present phase, as males have traditionally 'passed' this task - actually failed (i.e., 78.1% of the female subjects bettered the task criterion). It was felt that improved fitness on younger women and protocol modifications were responsible for this general improvement in performance; in earlier phases the stretcher carry had been conducted out-of-doors, on cinder tracks, and /or a second person (i.e., one laboratory personnel) required to carry the 'other end' of the stretcher.

In determination of the fifth percentile values for each group there were obvious differences between groups (see Table B3.6). For younger women < 35 years, oxygen consumption, sit-ups, ILM and flexed arm hang were related whereas for older women, all variables tested were related except sit-ups and push-ups. For men, oxygen consumption, sit-ups and endurance grip were related. Once again, these differences point out the difficulty in having a common EXPRES criteria for each group. In Table B3.7, the amount of overlap in data between passers and failers was shown. Of EXPRES variables sit-ups for women <35, grip for women ≥ 35 and VO_2 Max for men ≥ 35 were the only variables with a significant difference between the means for passers and failers of the task. The ILM score and flexed arm hang for both groups of women and also endurance grip for older women were significant. These facts highlighted the observation that EXPRES and other variables seldom show significant differences between passers and failers of the task despite the fact that these and other variables were related to performance (see Table 3.6). Once again these data reinforced the fact that prediction of performance based on simple fitness measures was not possible.

<u>B3.6 Conclusions</u>

This subset of fitness variables proved to be of limited value as discriminators of performance success on the stretcher carry task, while the additional laboratory tests improved performance prediction minimally. Therefore, the conclusions to be drawn concerning task performance were limited by the lack of definitive statistical relationships between fitness and performance.

1. These data suggested that a relationship exists between fitness (as measured by EXPRES and our laboratory tests) and performance of the land stretcher carry in that 31% to 57% of the variance in scores could be explained. However, as with previous studies general fitness measures cannot predict performance on the land evacuation task.
2. As concluded in both Phases I AND II, grip strength-endurance was again one of the most important fitness variable for women with oxygen consumption capacity having a relationship across all groups in this study.
3. Because of extenuating circumstances (discussed in section B3.5)

specific minimum values in this subset should be disregarded, in pushups for women.

More generally, the investigators recommend that the one-person stretcher carry to 750m, performed over an indoor hard-surfaced track, be considered as the standardized land evacuation task protocol, and that the 15-minute and 19.8 minute time be retained as the pass-fail criterion for younger and older subjects respectively in any future evaluation of CF personnel. This timed standard is a linear revision of the 20 minute standard for the original one kilometre task definition.

B3.7 Recommendations

The land evacuation task was selected as one of the test battery items in that it was considered on of the most physically demanding tasks within the designated list of Seven Common Tasks for CF personnel (excluding NBCW clothing which would raise the physiological requirements an undetermined amount). The task definition was fixed in terms of a timed criterion measure and from the standpoint that no assistive devices such as a shoulder strap was provided. Although the task was operationalized and improved to be a reliable one person task, it was not improved to optimize performance of all subjects. In a study conducted at DCIEM with and without shoulder straps on the stretcher, task performance times were markedly improved, especially for women. As the mass on the stretcher was 61.6% of the body weight, it is important to optimize the task protocol further; hence the following recommendation is made.

1. That an ergonomic redesign of the stretchers be carried out (shoulder straps added) so that the task definition is optimized prior to evaluation of subjects. Once again, it should be stated that the task protocol should be optimized prior to creating standards as this process potentially remove systemic bias form the

tasks. Only then is it appropriate to create screening tests to evaluate employee performance.

SECTION B4

SEA STRETCHER EVACUATION TASK ANALYSIS

SECTION B4

SEA STRETCHER EVACUATION TASK ANALYSIS

B4.1 Introduction

This common military task was a simulation of a casualty evacuation on board ship. As initially tasked by the CF, performance of the shipboard evacuation entailed a two-person team, while in firefighting gear, carrying an 80 kg person lying on a Stoker stretcher along a lower ship's deck a distance of 12.5 m, ascending up shipboard stairs, then returning, descending the stairs, and back along the lower deck to the starting point.

While conducting this emergency task in the field during Phase I, two major difficulties were encountered. Foremost, the task could not be performed by a single person, with the result that the Phase concept - evaluation of individual (physical) preparedness for this task - was not realized. Second, the only shipboard simulator on-land was located at the Forces Firefighting School at CFB Halifax, which proved both inconvenient and costly to employ for Phase purposes on any long-term basis. For Phase II, these deficiencies were redressed by redesign of the task, equipment, and data collection procedures. A large standing structure was fabricated replicating a CFB Halifax mock up of ship's upper deck and flight of stairs (see Appendix C). Then, with ground-level acting as the 'lower deck', this portable construction was reassembled at test sites to serve as the shipboard simulator. Built in to the superstructure as well, the carriage phase of the stretcher, both up, then down the stairs, was redesigned as a one-person task with the front half of a specially built Stoker stretcher running along metal tracks. The subject, positioned at the rear, lifted the equivalent of one-half the required 80 kg load, this weight being securely fastened inside the basket of the Stoker replication.

With these modifications the remodeled task took much less time than the 10-minute criterion originally sanctioned by the CF: in Phase II, the fastest person completed the redesigned task in 21 seconds, while even the slowest subject (physically capable of completing the task) required only 7 min: 24 sec. In Phase II, 75% of subjects bettered 210 seconds (i.e., 3.5 min), therefore, in consultation with DCIEM and ranking CF personnel, this time was established as the new pass/fail criterion, a drastic revision from the original benchmark but necessary in order to establish Phase values for this redesigned task. And finally, during Phase II split-times were also recorded at set intervals throughout the new task. These revisions were all carried through into the present phase.

B4.2 Task Rationale

Evidence supporting the higher energy costs of vertical work is convincing. Orsini and Passmore (1951), studying four different support and movement methods using a 37 kg load, concluded that compared to moving the same load overland, walking downstairs almost doubled subjects' energy requirements, while mounting stairs more than tripled their energy expenditures. Similarly, Astrand and Rodahl (1977) determined that continuous stair climbing while carrying 13.6 kg required 4.2 litres/min oxygen consumption, a near maximal value for their subjects; also, this resulted in near-maximal lactate values for both female and male subjects. Other aspects of load bearing have also been examined. Evans et al. (1983) compared the maximal time which their subjects could hold a 40 kg load (a compact box container) standing, versus carrying it on the level; under the latter experimental conditions the time to exhaustion was reduced but a near maximal heart rate response was recorded. Lind and McNicol (1966, 1967b, 1968) in a series of studies reported on the effects of load-carrying (20 kg) and recovery from such work. These investigators concluded that load distribution was important: an even distribution of the load improved performance significantly, and local fatigue was reduced. On the other hand, following exhaustion from load carrying a lengthy time period was required for complete recovery by subjects of their load-carrying capacity; this despite heart rate, blood pressure and local blood flow all having returned to pre-exercise conditions within 15 minutes. As well, if load-carrying was repeated before full recovery, subjects time to exhaustion was reduced accordingly (Lind & McNicol, 1967).

Results from our earlier studies in the Phase series found similar results. To carry a weighted Stoker stretcher up one flight of shipboard stairs elicited near maximal heart rates (for the female subjects in Phase II, 177 ± 13 and for males 160 ± 32 beats/min), elevated blood lactate post-exercise (in the females in Phase I, 65 ± 21 mg% and in males 60 ± 15 mg%), while producing moderate to extreme fatigue in all subjects (Stevenson et al, 1985 & 1986). On this basis the sea stretcher evacuation task was judged very physically demanding, requiring strength as well as other fitness components. However, because of the non-discriminating nature of these physiological responses (i.e., near-maximal but uniform in all subjects), physiological variables were not recorded during Phase II, with the exception of heart rate monitoring in subjects ≥ 35 years for safety purposes.

Of all the task modifications and changes made over the three phases by far, the greatest alterations have been made in the sea stretcher evacuation. However, the present investigators feel that the safety aspects of the task have been substantially improved. Considering the increased speed of movement and with personnel in full firefighting gear, the redesigned safety features permit the task to be performed with closer subject supervision at all times. And a system of pulleys can take the weight of the simulator at any instant during the task, such that should any untoward event suddenly occur, the subject can remain holding on securely to the end portion of the Stoker stretcher for support.

B4.3 Task Protocol

A replication of the rear half of a Stoker stretcher was connected by a movable apparatus to a flight of shipboard stairs. The stairs were designed such that one subject alone could carry the stretcher during ascent and descent of the stairs. The superstructure of the simulator was positioned securely with broad based foot supports stabilizing the structure on the cement floor in the Queen's University arena.

Subjects were instructed that the task should be completed quickly but carefully, with due concern for the safety of both the evacuee (simulated by affixed weights) and themselves. Fully dressed in firefighting gear, each participant was given opportunity to practice carrying the simulator, first unweighted, then partially weighted, until the subject felt both familiar and secure in moving up and down the flight of stairs. To further enhance personal safety a taut rope and pulley system was readied at all times to catch the weight of the simulator; attached securely to the top strut, the safety rope was controlled manually from the ground.

On the command "start", the subject was required to pick up the rear end of a Stoker stretcher (i.e., not the simulator at this point) and carry it (with a laboratory personnel carrying the front end) a horizontal distance of 12.5 m to the foot of the ship's stairs. The subject than switched to the end of the simulator and proceeded (alone) carrying the equivalently weighted simulator up to the top of the stairs; at the top deck there was opportunity to rest for as long as necessary with the safety rope mechanism holding the simulator before returning back down the stairs. Upon completion of the descent the subject switched back again to the rear end of the (real)

Stoker stretcher to resume carrying it the 12.5 m, returning to the start line (again with the laboratory personnel carrying the front end). In its entirety from start to finish, this simulation mimicked the continuous, 2-person, shipboard evacuation task; however, it offered the advantage that one person could be evaluated, unaided or fettered by the requisite 'second' person designated in the CF guidelines.

The variables measured were total time elapsed (in seconds) to complete the evacuation, as well as the following split-times: i)to the base of the stairs; ii)stairs ascent; iii)stairs descent; and iv) return to 'start line'.

B4.4 Results

B4.4.1 Descriptive Results

In Table B4.1, total times for completion of the sea stretcher evacuation and subjects' split-times are presented. On average, men $\geq$35 years completed the task in a faster time (under 2 min) than either of the female groups, and this trend was also reflected in their faster splits throughout the evacuation. Women <35 years completed the task on average in just under 2.5 minutes while the women $\geq$35 years required over 4 minutes. However, as on other common tasks, again the wide range of times for both the men and women's groups was worth noting. Overall, there was some overlap in times between (approximately) one-quarter of the women from both groups and the men. Comparing the fastest subjects in each group, men and women, there were only seconds separating both their splits and total times. By contrast on this task particularly, there was substantial time differences between the slowest males (requiring up to 1.5 min) and the women in both groups, <35 and $\geq$35 years, who required the most time to complete the task. Additionally, two of the women <35 and five female subjects $\geq$35 years were physically unable to complete this evacuation task.

Table B4.1 Summary of Shipboard Evacuation Task Performance Scores of the Sample by Age Group and Sex.

	Split Times (s) Start to Stairs	Up Stairs	Down Stairs	Total Time (s)
Women < 35 years n= 57				
Mean	6.1	114.9	136.5	148.0
SD	1.3	147.9	153.8	158.3
(min-max)	(4-10)	(14.3-699.9)	(21.8-73.3)	(27-747)
Women ≥ 35 years n= 23				
Mean	7.6	214.4	245.1	259.5
SD	2.8	221.9	235.4	244.1
(min-max)	(4.7-14.7)	(21.1-756.9)	(29-893)	(36-912)
Men ≥ 35 years n= 62				
Mean	5.1	22.5	33.3	40.1
SD	1.3	10.4	14.0	15.1
(min-max)	(3.4-10.7)	(11.7-65.1)	(16.8-86.9)	(21-97)

B4.4.2 Simple Correlations

Tables B4.2a and b present correlation analysis results comparing EXPRES and laboratory test variables to performance times, specifically, total time to completion of the task in Table B4.2a, and split-times in Table B4.2b. All r-values correlating fitness and total times were found to be low and non-significant; on the other hand in Table B4.2a, of 21 fitness-related coefficients 20 were determined to be negative values. In Table B4.2b all but one r-value correlating subjects' fitness test results and their split-times through the sea evacuation were found to be non-significant but, again, of 63 fitness related coefficients 62 were related to improved fitness.

B4.4.3 Stepwise Regressions

Results of the stepwise regression analyses predicting total time for the sea stretcher evacuation by EXPRES and laboratory test variables are shown in Table B4.3. For women <35 years, in their regression equation only their flexed arm hang and no other fitness variables appeared as significant ($p<0.001$) predictors, which accounted for only 18% of the variance in total evacuation time. Similarly, for women ≥35 years, only one fitness variable appeared in their regression equation, maximal grip strength, but accounted for much more of the variance, 40%. By comparison, for the men ≥35 years, a combination of these fitness factors was determined to be predictors of their sea stretcher performance: flexed arm hang-time and, in this case, their endurance grip strength. However, even together, these two fitness variables accounted for only 26% of the variance in their sea stretcher performance.

In Table B4.4, blocked regression analyses are presented with total time for completion of the sea evacuation regressed on fitness variables when the latter were blocked according to the major components (i.e., muscle strength-endurance and aerobic capacity). For the women's groups only 19% of the

Table B4.2a Correlations Between Shipboard Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Total Time.

	Women <35	Women ≥35	Men ≥35
Anthropometry			
Age	.18	-.05	.24
Height	-.32	-.65	.03
Weight	.09	.10	.16
Muscular Strength and Endurance			
Situp	-.20	-.31	-.30
Pushup	-.21	-.08	-.32
Combined Grip	-.13	-.27	-.02
Endurance Grip	-.25	-.56	-.40
Flexed Arm Hang	-.42	-.53	-.43
Maximum ILM to Full Extension	-.27	-.27	-.25
Aerobic Capacity			
Step test	.38	-.32	-.32

Note.* p<.001.

Table B4.2b Correlations Between Shipboard Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Split Times.

	Start to Stairs			Up Stairs			Down Stairs		
	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35	Women <35	Women ≥35	Men ≥35
<u>Anthropometry</u>									
Age	.37	.03	.13	.17	-.04	.25	.17	-.05	.23
Height	-.22	-.43	-.06	-.32	-.67	.06	-.31	-.66	.04
Weight	-.10	-.15	.03	.06	.12	.18	.07	.10	.15
<u>Muscular Strength and Endurance</u>									
Situp	-.41	-.20	-.26	-.20	-.34	-.30	-.20	-.31	-.29
Pushup	-.19	.27	-.20	-.19	-.08	-.30	-.20	-.07	-.31
Combined Grip	-.37	-.62	.08	-.12	-.63	-.03	-.12	-.63	-.04
Endurance Grip	-.19	-.48	-.22	-.25	-.56	-.37	-.25	-.56	-.40
Flexed Arm Hang	-.22	-.37	-.30	-.39	-.53	-.38	-.41	-.52	-.40
Maximum ILM to Full Extension	-.48*	-.22	-.19	-.25	-.26	-.18	-.27	-.26	-.24
<u>Aerobic Capacity</u>									
Step test	-.17	-.21	-.30	-.09	-.34	-.33	-.11	-.31	-.31

<u>Note</u>. * p<.001.

Table B4.3 Stepwise Regression of Shipboard Evacuation total time on fitness parameters by sex and age level.

Variables in Equation	B	SE B	Mult. R.	R^2	F	p
Women < 35 years						
Constant	233.78	31.39				
Flexed Arm Hang	-4.07	1.21	.42	.18	11.34	.001
Women ≥ 35 years						
Constant	1092.20	224.83				
Maximum Grip	-13.71	3.64	.63	.40	14.17	.001
Men ≥ 35 years						
Constant	58.07	4.60				
Flexed Arm Hang	-.31	.09	.41	.17	11.22	.001
Endurance Grip	-.04	.02	.51	.26	9.85	.001

Table B4.4 Shipboard Evacuation total time regressed on EXPRES and other laboratory tests blocked for fitness components.

Block	R^2 Eqn.	F Eqn.	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	.20	4.02	.05	.20	4.02	.05
Strength and Endurance	.40	2.99	.01	.19	2.17	NS
Aerobic Capacity	.40	2.68	.05	.004	.33	NS
Women ≥ 35 years						
Anthropometric	.48	5.28	.01	.48	5.28	.01
Strength and Endurance	.67	2.49	NS	.19	1.05	NS
Aerobic Capacity	.68	2.14	NS	.01	.35	NS
Men ≥ 35 years						
Anthropometric	.07	1.35	NS	.07	1.35	NS
Strength and Endurance	.30	2.24	.05	.23	2.57	.05
Aerobic Capacity	.31	2.04	NS	.01	.47	NS

variance in task performance was accounted for by their strength-endurance, while 23% was accounted for by the men's strength-endurance component. However, for all three groups of subjects ≤1% of the variance was accounted for by aerobic capacity. On the other hand, for women ≥35 years anthropometric parameters accounted for 48% of the change in R^2, however, this also was found to be non-significant ($p>0.001$).

B4.4.4 Criteria for Passing the Task

The sea evacuation task changed markedly from its conception in Phase I in that an operational task was created to replace the two person task definition. As a result the original 10 minute time criteria was no longer appropriate. In Phase II, 75% of the men and women completed this task in 210 seconds or 3.5 minutes. As a result this time standard was used for women <35 for this study. The adjusted time for older subjects was 277 seconds based on the heart rate restriction substudy and an equal sample of older men and women (Table A11). By these criteria and for this Phase, 25% of women <35 years and 35% of women ≥35 failed the task criteria. As in Phase II all older men passed the task criteria for the sea evacuation task.

B4.4.5 Discriminant Analysis

Discriminant function analyses using a stepwise procedure testing both EXPRES and the other fitness variables are presented for the women (only) in the present study in Table B4.5 (i.e., see footnote below Table). Flexed arm hang-time again appeared as a common parameter for both groups in addition to, for the women <35 years, their maximal ILM lift, and for women ≥35, their endurance grip scores. And while these functions identified 77% and 78% (respectively) of the subjects, the functions themselves were not significant (at the 0.001 level of confidence); that is, in neither case could the function reliably discriminate between each group's 'passers' and 'failers'.

Table B4.5 Discriminant analysis and classification results by EXPRES and Queen's variables in groups defined by Sea Stretcher Evacuation pass fail status.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	%	Predicted Performance Correctly Classified n	%	Incorectly Classified n	%
Women < 35 years								
ILM	0.35	Pass	43	(75)	41	(95)	2	(5)
Flexed Arm Hang	0.85	Fail	14	(25)	3	(21)	11	(79)
		Total	57		44	(77)	13	(23)
Wilks' Lambda:	0.80							
Chi-Squared:	12.38							
Significance Level:	0.01							
Canonical Correlation:	0.45							
Women ≥ 35 years								
Endurance Grip	0.56	Pass	15	(65)	15	(100)	0	(0)
Flexed Arm Hang	0.56	Fail	8	(35)	3	(38)	5	(63)
		Total	23		18	(78)	5	(22)
Wilks' Lambda:	0.69							
Chi-Squared:	7.38							
Significance Level:	0.05							
Canonical Correlation:	0.56							

Note. All of the Men ≥ 35 years passed this task.

B4.4.6 Fifth Percentile of the Passing Group

In Table B4.6, the PASSERS within the individual groups (i.e., only the subjects bettering the pass criterion of 3.5 min) are profiled according to minimum EXPRES and laboratory scores. These values incorporated a similar subset of minimum EXPRES values (and in five instances minimum values are identical) as determined in the preceding sections for the low high crawl and the land evacuation (see sections B2.4 and B3.4, respectively):

1. MPFS requirements for all three groups of subjects in the present study for VO_2 Max and sit-ups were both comparable to . .tablished MPFS standards (Stevenson et al., 1986) and compatible with Canadian norms (i.e., <30th %ile, according to sex and age grouping; Reid & Thomson, 1985: pp.126 & 142).
2. Minimum grip for men $\geq$35 years was in close agreement both with MPFS values determined in our earlier studies as well as on the other tasks in the present study. On the other hand, while minimum grip for women is established at (approx.) one-half the Phase for men, the values for both groups of women in Table B4.6 are high, and, again, particularly so for the women <35 years (i.e., at the 66th %ile according to national norms; Reid & Thomson, 1985: p.129) as noted consistently throughout section B in this Report.
3. In Table B4.6 minimum push-ups for both groups of women (again) produced <u>negative</u> values as a result of the normalized z scores for the passing group; as argued earlier in this Report, the drastic change in pushup technique for the present study was felt responsible for this spurious finding.
4. Minimum push-ups for men $\geq$35 years were also surprisingly low, one-half of their established Phase of 14 (Stevenson et al, 1986), and particularly low considering their relatively high scoring on

Table B4.6 Fifth percentile scores for personnel passing Sea Evacuation by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	56.3	49.5[bd]	73.5
VO_2 Max	31.2	28.0	30.7
Situps	13.3	9.9	15.6
Pushups	-1.3	-2.5	7.0
Queen's			
ILM	23.5[ab]	17.6	36.6
Endurance Grip	13.3	13.5[ab]	59.4[d]
Flexed Arm Hang	-4.0[abd]	-7.1[a]	2.8[d]

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

EXPRES (i.e., as a group, 27.1±13.5 push-ups, well above the 75th %ile on Canadian norms; Reid & Thomson, 1985: p.127).

Table B4.6 also summarizes the findings of the earlier analyses carried out on subjects' sea evacuation data throughout this section (see Table footnotes) to indicate the relative importance of fitness variables to each of the groups in terms of evaluating task performance. In only one instance was an EXPRES variable found significantly related to performance (see grip Phase for women ≥35 years); otherwise, EXPRES was shown to be unrelated to the sea stretcher task. Similarly, examining across the rows, the laboratory tests were identified as significant variables in task performance in only a few analyses but, compared to similar analyses carried out in the other B sections of this Report, these were neither consistent across groups nor within groups.

B4.4.7 Impact of Passing and Failing

In Table B4.7, the fitness scores of the women, both <35 and ≥35 years, passing and failing the sea stretcher task were analyzed (i.e., as footnoted in Table B4.5, all of the men ≥35 years bettered 3.5 min): individual averages for 'passers' versus 'failers' on each EXPRES and laboratory test were compared (by Student t-test, with significance accepted at the 0.0^ level in this instance only). Of the 14 comparisons only 5 proved to be significantly different, however in every case the trend was identical with the passers' fitness scores always proving the higher value. And, in fact, a similar trend can be observed examining all comparisons: in every instance the mean score of the passing subgroup was higher, however, in the nine comparisons found non-significant ($p>0.01$) several of the numerical differences were marginal (i.e., almost numerically equivalent).

Table 4.8 is designed to examine the impact of the proposed standards from Table A14 (based on all tasks) on the sea evacuation task. The overall

Table B4.7 EXPRES and Laboratory fitness scores of 'passers' vs 'failers' on the Shipboard Evacuation Task.

Variable		Women < 35 Pass		Women < 35 Fail	Women ≥ 35 Pass		Women ≥ 35 Fail	Men ≥ 35 Pass	Men ≥ 35 Fail
EXPRES									
Max Grip	M	75.0		70.1	64.3	*	54.0	109.1	---
	SD	(11.4)		(8.4)	(9.1)		12.5	(21.7)	---
VO_2 Max	M	37.2		36.7	33.9		32.3	40.4	---
	SD	(3.7)		(3.6)	3.6		3.6	(5.9)	---
Situp	M	34.3		28.6	27.7		20.9	31.3	---
	SD	(12.8)		(7.5)	10.8		7.4	(9.6)	---
Pushup	M	20.4		13.6	10.5		8.9	26.2	---
	SD	(31.2)		(6.6)	7.9		11.3	(11.7)	---
Queen's									
ILM	M	31.9	*	28.6	27.8		24.1	51.9	---
	SD	(5.1)		(4.6)	6.3		3.0	(9.4)	---
Endurance Grip	M	88.8		71.2	123.3	*	56.1	226.1	---
	SD	(46.0)		(43.2)	66.9		21.5	(101.7)	---
Flexed Arm Hang	M	24.6	*	7.6	17.2	*	2.5	30.1	---
	SD	(17.4)		(7.4)	14.8		3.4	(16.6)	---

Note. * Reliable difference ($p < .01$) between passing and failing group means.

Table B4.8 Impact of fitness standards on classification by pass/fail status for Sea Evacuation task.

Fitness Test Performance	Sea Evacuation Task Performance			
	Correctly Classified (no)	Correctly Classified (%)	Incorrectly Classified (no)	Incorrectly Classified (%)
Pass EXPRES	99	70.2	14	9.9
Fail (1 or more)	8	5.7	20	14.2
Total	107	75.9	34	24.1

standards would have placed 24% of the subjects in the wrong category with 14.2% of the subjects who would have failed EXPRES but passed the task. This proportion of false negatives was higher than acceptable in single task examination.

B4.5 Interpretation

Over our three Phases of the study, the sea stretcher evacuation has been considerably altered compared to the task originally defined in the CF guidelines. Foremost, however, the present protocol now conforms to the template applied to all other common military tasks, assessment of individual performances, yet, completing the redesigned task subjects perform an identical amount of work lifting and carrying. However, the much faster split-times recorded throughout the evacuation as well as total time to completion have raised a number of concerns both experimental and practical. First, in order to evaluate performance success in Phase II, the CF's criteria of 10 minutes total time for passing versus failing was drastically reduced (i.e., to 210 seconds, see discussion section A3.4; Stevenson et al, 1986). Compared to Phase II results for the women <35 years their, total and split times for the one-person evacuation in the present study were quite similar. On the other hand, the other 'repeater' group (from Phase II), men ≥35 years, were almost 50% faster in the present study (i.e., 74.9±45.7 sec in Phase II versus 40.1±15.1 sec), as were the women ≥35 years in the present study (but note that only three of eight women completed this task in Phase II). Second, however, overall only 16% of subjects failed to achieve the modified performance criterion in the present study (i.e. modified according to the Phase II where 25% of all subjects had failed). But on closer inspection the percentage breakdown of subjects passing versus failing in the 'repeater' groups from Phase II was [illegible]ite comparable: 100% of men ≥35 years, the same as in Phase II, and 76% of women <35 years (versus 78% in Phase II). Third, subjectively, performing the modified protocol, this task was felt to be much safer while permitting more rigorous experimental control during testing. The risks of falling on the stairs and lower back injuries were greater performing this task as originally designed in the CF guidelines because of the precarious positions personnel had to assume at specific junctures through the two-person task protocol. Fourth, as concluded in our Phase II Final Report (Stevenson et al, 1986), from both the monetary perspective and in terms of convenience the modified protocol was again judged vastly superior to relocating our entire laboratory as well as CF personnel to CFB Halifax, as was necessitated in Phase I by the initial design of the task and two-person protocol. The portable superstructure replicating a ship's stairs and upper deck can now be reassembled at any testing site (in Phase II at CFB Borden, then CFB Uplands, in the present study in the arena at Queen's University).

In both Phase I and II the relationship between subjects' fitness, as determined by EXPRES and the laboratory tests, and their sea stretcher performance scores was low (Stevenson et al, 1985 & 1986). However, by comparison with even these data, our univariant analyses revealed less relationships: in Phase II 13 (of 177) coefficients were found to be significant, while in the present study only one r-value (of 83 fitness-related coefficients) proved significant ($p<0.001$). On the other hand, in all MPFS phases the large majority of the fitness-related coefficients have appeared as negative values: in the present study 81 (of 83), and in Phase II 159 (of 177) r-values were negative. As found with all other common military tasks, this strongly negative relationship between fitness and performance again underscored that an underlying relationship does exist between subjects' physical fitness and their task scores - in this case, specifically with their sea evacuation performance. Finally, our additional univariant analyses, first attempted in Phase II correlating subjects' split-times through the sea evacuation with individual fitness scores, again did not result in any higher (nor significant) r-values, verifying our earlier conclusion regarding this analytical means of evaluating subject performance that total time (for completion of the sea evacuation) was in fact the single, best quantitative measure for evaluating subjects' performance (Stevenson et al, 1986).

Through the three phases of MPFS, unfortunately our multivariant analyses have not improved the predictive value of EXPRES or the laboratory tests in evaluating subject performances. On the other hand, our bases for comparison on the sea stretcher task year-to-year has changed because the task itself has been progressively modified, the major redesign in task performance being made prior to Phase II. From Phase I, upper body strength as measured by push-ups was the only fitness-related parameter found; in Phase II, both leg and upperbody strength appeared as significant predictors for the various groups; and from the present regression analyses arm and grip strength appeared as significant predictors of performance. On the other hand, what has remained relatively constant from Phases I through III was the modest portion of the variance accounted for by these various subsets of fitness variables: in Phase I 20%, in Phase II 26%, and in the present study 40% were the highest R^2 values associated with fitness-related variables. By contrast, there has been a surprising degree of agreement between results when fitness components have been blocked. Comparing results for women <35 and men ≥ 35 years between Phase II and the present study (i.e., the two groups of 'repeaters' in Phase III): strength-endurance accounted for between 19% to 23% of the variance in performance scores for these subjects independent of group, with aerobic capacity always accounting for $\leq 6\%$. Additionally, subjects' anthropometric parameters blocked have consistently accounted for only $\leq 10\%$ of the changes in R^2 (with one exception in Phase III for women <35

years, 20%). Finally, from our three Phase studies discriminant analysis produced only one significant function (at the accepted 0.001 level of confidence); otherwise, results of our multivariant analyses have proven quite tentative for the sea stretcher task as well.

In terms of the fifth percentile scores, only grip from EXPRES for women $\geq$35 had a reliable relationship (Table B4.6) to performance. Of the additional tests, ILM and flexed arm hang were related for women <35 and endurance grip and flexed arm hang for women and men $\geq$35. The small number of relationships and the lack of differences between passers and failers would indicate that the general fitness measurements evaluated in this contract were not adequate to predict performance. The sea evacuation task required a skill, coordination and tenacity components which were not measured by these variables. Hence it was not surprising that only 18%-40% of the variance in data was explained by fitness variables.

B4.6 Conclusions

The subset of EXPRES Phase variables proved to be of limited value as discriminators of performance success on the sea stretcher task, while the additional laboratory tests improved performance prediction minimally. Therefore, the conclusions to be drawn concerning task performance are limited by the lack of definitive statistical relationships between fitness and performance.

1. These data suggest that there was limited relationship between one's fitness (as measured by EXPRES and our laboratory tests) and performance of the sea evacuation task which was adequate to account for 18% to 40% of the variance in task performance. As with previous studies, results were consistant in that it was not possible to predict sea evacuation scores from general fitness

parameters.

2. No EXPRES parameters except for maximum grip for older women were significantly related to task performance. In addition all men passed the task in two years of testing whereas 25% and 35% of young and older women respectively failed this years task protocol.

3. Because of extenuating circumstances, again specific minimum values in this subjset should be disregarded, in particular MPFS push-ups for women.

More generally, the investigators recommend that the one-person, Stoker stretcher protocol and equipment superstructure be considered as the standardized sea evacuation task, and that 210 seconds (3.5 min) be evaluated as the criterion time for completion of this protocol. Older subjects would be required to complete the task in 277 seconds (4.6 minutes).

B4.7 Recommendations

The sea evacuation task was selected as one of the test battery items that was one of the most physically demanding within the designated list of Seven Common Tasks for CF personnel. The revised task protocol was considered an improvement over the original definition in that it was a one person task, it resembled the work requirements of the original task, and it was a reliable task protocol. The major concern is that women only failed the task. Task design may have been a problem, as indicated by a relationship between height and task score for older women ($r=-.65$ $p<.001$). Women frequently complained that the riser height of steps was one of the main difficulties encountered with task completion and faster task times. Therefore it is recommended that:

1. The sea evacuation stairs be redesigned with shorter rise height on steps (more like ship steps than CFB Halifax Fire Fighting School steps) so that the design of the task be optimized for all subjects.

SECTION B5

ENTRENCHMENT DIG TASK ANALYSIS

SECTION B5

ENTRENCHMENT DIG TASK ANALYSIS

B5.1 Introduction

Originally this task was intended to simulate individual dig emplacements which, in actual combat, provide personnel protection against incoming enemy fire. As initially tasked by the CF, personnel were allowed 45 minutes to dig their entrenchment "...to a depth of 0.45 m in soil of medium firmness with no rocks or large roots using the entrenching tool...the foxhole (being) approximately 1.8 m long x 0.6 m wide".

However, while conducting this field test during Phase I insurmountable problems were encountered. During our initial preliminary testing conducted in May, 1985, employing CF personnel, and in June, employing civilian subjects, ground conditions at CFB Kingston were optimal for the dig emplacement as tasked. By end of July during data collection for Phase I, due to lack of rain the clay-based soil at CFB Kingston had dried to rock-hard, whereas the CF's task definition specified "soil of medium firmness". And while subjects gave their best efforts, results for the dig emplacement were at best spurious. Only 44% of male personnel completed the dig within 45 minutes, compared to our preliminary study conducted earlier in May on the <u>same</u> dig site where 100% of males (n=12) bettered the completion time criterion; even more telling, during preliminary work the fastest time overall (20 minutes) was recorded by one of the females yet during our main data collection in July no female subject (n=21) completed the dig in under 45 minutes. Further, preparing for Phase II, to be conducted at CFB Borden and Uplands, while open areas for digging could be made available at Borden, in between buildings at CFB Uplands the larger areas are paved for parking, the smaller areas sod covered and landscaped.

Therefore, with contractual approval, a box-hole dig was developed for Phase II in an effort to standardize testing protocol, and in particular to achieve consistent soil conditions as well as to eliminate the unsightly mess left by field digs. However, one major outcome of the revised protocol was a dramatic reduction in dig time: the fastest males and females completed the box-hole dig in 2-4 minutes, and the very slowest in well under 20 minutes.

B5.2 Task Rationale

Summaries of previous studies of military personnel (Passmore & Durnin, 1955) and coal miners (Morrissey et al., 1983) indicated that digging requires significant energy expenditure. From military studies, Passmore & Durnin examined work outputs which ranged from 276 kcal/hr. to 528 kcal/hr. The most recent estimation of coal-miner's energy expenditure was 408 kcal/hr. (Morrissey et al., 1983). Chakraborty et al. (1974) determined that oxygen consumption was sustained at 29.1 ml/kg/min, the equivalent of up to 69% of their subjects' maximal aerobic capacity, while heart rates have been sustained well over 130 beats/min during prolonged digging. On the other hand, only a modest rise in blood lactate has been recorded, 34.8 mg% post-dig (Chakraborty et al., 1974). In summary, it appeared that workers naturally select an optimal energy expenditure of approximately 400 kcal/hr. This work rate permitted a high peak efficiency while digging over a prolonged period of time without experiencing undue fatigue; this corresponded to an oxygen consumption of approximately 1.5 litres/min. In Phase I of MPFS, subjects' heart rate responses to digging their emplacements reflected a similar elevated rate of working throughout: for both male and female CF personnel 155 - 160 beats /min (Stevenson et al., 1985). Therefore, during digging tasks energy was expended at a constant, submaximal rate approaching 70% of maximal aerobic capacity, and equivalent to

400 kcal/hr. for males, slightly less (10-15%) for females. In Phase II the heart rates apprached 90% maximal aerobic capacity and the caloric cost proportionately. However, since physiological parameters discriminated between subjects minimally, both in Phase II and the present phase only subjects' performance times were recorded, with heart rate monitoring being employed only with personnel ≥35 years in the interests of safety.

For Phase II a box-hole dig was developed, a wooden box dimensioned 1.8m in length x 0.6m width x 0.45m depth was built and enclosed within a wooden superstructure to prevent the soil contained therein from being sprayed about as the box was being emptied during testing (for details see Appendix C). Finely crushed rock less than 1 cm in size was substituted for top-soil which made digging easier; by comparison with earlier studies, the box-hole dig produced a much shorter task, completed by the majority of personnel in under 10 minutes in Phase II (Stevenson et al., 1986). However, the box-hole dig proved a superior test than the entrenchment dig from the standpoint of experimental control and subject safety. The confines of the box ensured that all subjects removed the identical volume of soil; this variable had been judged a source of major error in field digging. The consistency of the crushed rock soil was always uniform, and of constant moisture content. And during mass testing, subjects were closely monitored one-at-a-time, as opposed to field digs where many entrenchments proceeded at one time; with the need to monitor subjects ≥35 years, the latter field format potentially placed these subjects at risk without closer supervision. And in any case, outdoor field conditions varied daily with weather conditions, even when ideal top-soil conditions were realized. In summary, to transfer the intent of the dig emplacement task with both its physiological and performance prerequisites intact directly into the experimental situation proved difficult on several counts. Consequently, the results and discussion presented below must be tempered by these factors and limitations of the protocol.

B5.3 Task Protocol

The purpose of this task was to dig an entrenchment measuring 1.8m x 0.6m x 0.45m as quickly as possible. To standardize testing conditions and eliminate the effects of inclement weather, the dig site was moved indoors. A wooden structure, built off the floor, was used to simulate outdoor dig conditions. Its construction featured two identical wooden boxes (both 0.47 m^3 inside area), one filled with finely crushed rock, the other immediately along side empty. The crushed rock was always dampened by water to control dust. High sideboards were enclosed on three sides of the box to prevent the spread of crushed rock about the floor (see Appendix C for details).

The subject was required to dig from one box, pitching the crushed rock by spade into the adjacent (and empty) box. On the command "start", the subject commenced digging. When necessary through the dig, subjects could rest. Subjects $\geq$35 years were monitored such that when their heart rates reached 90% of their predicted maximum they were stopped, resting until sufficiently recovered to continue. The task was complete only when the laboratory personnel overseeing the entire box-hole area, said "stop". In order to achieve uniformity, test personnel judged when the box was emptied, and often this required subjects to scoop out the final bits of soil by hand, particularly from tight corners where the spade had difficulty in reaching. In the interests of safety, subjects wore heavy work gloves and a wide weight-lifting belt fastened tightly around the waist and lower back.

The variables recorded were: i)total time to complete the dig; ii) rate of shoveling (the number of full shovel fulls were counted and recorded at the beginning and half way through the dig.

B5.4 Results

B5.4.1 Descriptive Results

In Table B5.1, subjects' times for completion of the entrenchment dig are presented. On average, the men ≥35 years, all of whom had to be either paced or stopped during their dig, required 6 minutes 49 seconds. By comparison, on average women <35 years completed the dig in 8 min. 18 sec while the women ≥35 years required 10 min. 30 sec. The fastest times for the dig were 3 min.36 sec for one male and less than a minute longer, 4 min. 16 sec, for the fastest female (<35 years); the fastest woman ≥35 years required only 6 min. 13 sec to complete the dig. As noted for all tasks, again, considerable overlap was observed between the times recorded by the female and male subjects. For shovel rates, almost all subjects began quickly and then moved into a steady pace.

B4.4.2 Simple Correlations

Table B5.2 presents results of correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to their total times for the box-hole dig. Only two of 21 fitness-related r-values were found to be significant ($p<0.001$). All but one of these coefficients appeared as negative values; in other words, the faster the time, the higher the fitness score.

Stepwise regression analyses of box-hole dig total time on fitness parameters are summarized in Table B5.3. For women <35 years, two significant ($p<0.001$) variables were identified, maximal ILM and grip strength, which accounted for 38% of the variance in dig time. On the other hand, for both groups of subjects ≥35 years, women and men, only one fitness variable was identified for each group, endurance grip and ILM (respectively), however each accounted for much smaller changes in R^2 (only 22% and 8%, respectively) and were found to be non-significant ($p>0.001$).

Table B5.1 Summary of Entrenchment Task Dig Performance of the Sample by Age Group and Sex.

	Total Time (s)
Women < 35 years	
n= 59	
Mean	498.2
SD	135.7
(min-max)	(256-953)
Women ≥ 35 years	
n= 28	
Mean	630.5
SD	180.4
(min-max)	(373-1081)
Men ≥ 35 years	
n= 63	
Mean	408.9
SD	136.6
(min-max)	(216-809)

Table B5.2 Correlations Between Entrenchment Dig Total Time and Fitness Parameters by Sex and Age Level.

	Women <35	Women ≥35	Men ≥35
Anthropometry			
Age	.08	-.04	.21
Height	-.33	-.42	-.09
Weight	-.22	-.19	-.21
Muscular Strength and Endurance			
Situp	-.28	-.11	-.27
Pushup	-.35	-.19	-.17
Combined Grip	-.43	-.46	-.14
Endurance Grip	-.50*	-.43	-.25
Flexed Arm Hang	-.43	-.11	.09
Maximum ILM to Full Extension	-.62*	-.23	-.31
Aerobic Capacity			
Step test	-.16	-.40	-.27

Note. * $p < .001$.

Table B5.3 Stepwise Regression of Entrenchment Dig total time on fitness parameters by sex and age level.

Variables in Equation	B	SE B	Mult. R.	R^2	F	p
Women < 35 years						
Constant	1061.70	111.45				
ILM	-11.92	2.63	.57	.32	24.72	.001
Max Grip	-2.77	1.29	.61	.38	15.51	.001
Women ≥ 35 years						
Constant	750.27	.54				
Endurance Grip	-1.32	63.15	.47	.22	6.03	.05
Men ≥ 35 years						
Constant	615.72	92.39				
ILM	-3.96	1.74	.29	.08	5.19	.05

In Table B5.4, results of regressing total time on EXPRES and laboratory scores blocked for fitness components are presented. For women <35 years, the only significant ($p<0.001$) block of variables was that of strength-endurance, evidencing changes in R^2 of 0.40. For the other two ≥35 groups, both women and men, no significant blocks appeared (at the accepted 0.001 level of confidence).

B5.4.4 Criteria for Passing the Task

In Phase I, the original task definition of an entrenchment in medium soil contained a passing criteria of 45 minutes. This criteria was not suitable for the operationalized task where all subjects completed the task in less than twenty minutes. As a result, a new standard was created based on a representative sample of men and women <35 years in Phase II. The passing criteria was set at 510 seconds or 8.5 minutes, the point at which 75% of the sample passed the task. This passing criteria was maintained for the women <35 for this study.

To create an age adjusted correction factor for men and women ≥35 years, an equal sample of women (28) and three random samples of 28 men were averaged and results pooled to determine the frequency histogram for this task. The 75% cut off time was 32% of unrestrained subjects at 11 min. 15 seconds or 673 seconds. This process was double checked in a substudy using 16 men and 3 women where they were asked to do both a restrained and unrestrained dig under medical supervision (Table B5.5). These subjects were also given a maximal oxygen consumption treadmill test by a physician in order to determine true maximal heart rate and aerobic capacity. Results of this study showed a 36.3% decrease in dig time for men and a 31.0% decrease in dig time for women. Thus with these two studies, a correction factor of 32% was used to adjust the target time for men and women ≥35 to account for the handicap of a heart rate

Table B5.4 Entrenchment Dig total time regressed on EXPRES and other laboratory tests blocked for fitness components.

Block	R^2 Eqn.	F Eqn.	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	.08	1.41	NS	.08	1.41	NS
Strength and Endurance	.48	4.21	.001	.40	5.23	.001
Aerobic Capacity	.48	3.70	.01	.00003	.002	NS
Women ≥ 35 years						
Anthropometric	.23	1.72	NS	.23	1.72	NS
Strength and Endurance	.62	1.98	NS	.39	1.85	NS
Aerobic Capacity	.87	6.91	.01	.25	20.17	.01
Men ≥ 35 years						
Anthropometric	.15	3.18	.05	.15	3.18	.05
Strength and Endurance	.31	2.38	.05	.16	1.83	NS
Aerobic Capacity	.34	2.37	.05	.03	1.89	NS

Table B5.5 Raw data and summary statistics for subjects who performed the entrenchment dig under restricted and unrestricted conditions.

			Unrestricted Performance		Restricted Performance	
Subject I.D.	Age In Years	*Maximal Oxygen Consumption ml/kg/min	True 100% Heart Rate beats/min	Entrenchment Dig (100%) seconds	Predicted 90% Heart Rate beats/min	Entrenchment Dig (90%) seconds
Males						
1409	35	47.4	200	305.6	174	566
1503	35	48.8	208	226.9	174	464
1602	36	45.8	189	285.5	173	445
1301	38	31.8	190	238.9	171	216
1604	38	45.0	209	359.2	171	646
1702	38	44.3	183	510.8	171	470
1804	38	44.6	186	361.6	171	316
1603	40	32.6	189	217.9	169	301
1703	40	39.5	165	369.3	169	300
1701	41	37.0	176	317.0	168	375
1302	44	36.2	173	317.8	165	260
1401	44	28.8	176	333.6	165	604
1403	45	36.6	189	266.3	165	501
1404	45	45.8	181	245.0	165	637
1803	49	37.2	175	268.8	161	273
1801	49	40.6	179	234.0	161	248
Mean		40.88	185.81	303.62	161.54	413.88
S.D.		5.28	11.70	72.28	29.73	142.34
Females						
1709	39	33.3	197	448.9	170	490
1509	40	39.8	185	325.0	169	483
1305	40	36.3	184	487.7	169	680
Mean		36.47	188.67	420.53	169.33	551
S.D.		2.66	5.91	69.36	0.47	91.26

* A maximal oxygen consumption test was used to determine true maximal heart rate.

restriction. The target time for older subjects was set at 673 seconds (see Section A5.4 for further data analysis).

B5.4.5 Discriminant Analysis

In the discriminant function analyses when the passing/failing criteria were established, results were similar to the regression analyses (Table B5.6). The function determined for the women <35 years, including the endurance variables of flexed arm hang and grip, correctly classified 75% of these subjects. The functions for both groups of subjects ≥35 years contained several more variables with slightly better classification for women (79%) and even more for older men (93%).

B5.4.6 Fifth Percentile of Passing Group

In Table B5.7, the PASSERS within the individual groups (i.e., only the subjects bettering the pass criterion of 8.5 min. for <35 years and 11.2 min for ≥35 years) are profiled according to minimum EXPRES and laboratory test scores. These values incorporated a similar subset of minimum EXPRES values (and in four instances minimum values were identical) as determined in the preceding sections for the low high crawl and the two evacuation tasks, land and sea, sections B2.5, B3.5 and B4.5 (respectively):

1. MPFS requirements for all three groups of subjects in the present study for VO_2 Max and sit-ups were both comparable to established MPFS standards (Stevenson et al., 1986) and compatible with Canadian norms (i.e., <30th %ile, according to sex and age grouping; Reid & Thomson, 1985: pp.126 & 142).
2. Minimum grip for men ≥35 years was in close agreement both with MPFS values determined in our earlier studies as well as on the other tasks in the present study. On the other hand, while minimum grip for women is established in the 40-45 kg range (Stevenson et al,

Table B5.6 Discriminant analysis and classification results by EXPRES and Queen's variables in groups defined by Entrenchment Dig pass fail status.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	Performance %	Predicted Performance Correctly Classified n	Correctly Classified %	Incorectly Classified n	Incorectly Classified %
Women < 35 years								
ILM	0.32	Pass	37	(63)	35	(95)	2	(5)
Endurance Grip	0.55	Fail	22	(37)	9	(59)	13	(41)
Flexed Arm Hang	0.54							
		Total	67		44	(75)	15	(25)
Wilks' Lambda:	0.71							
Chi-Squared:	19.10							
Significance Level:	0.001							
Canonical Correlation:	0.54							
Women ≥ 35 years								
Max Grip	0.91	Pass	17	(61)	15	(88)	2	(12)
VO_2 Max	0.87	Fail	11	(39)	7	(64)	4	(36)
Flexed Arm Hang	-1.20							
Pushups	0.76							
ILM	0.40							
		Total	28		22	(79)	6	(21)
Wilks' Lambda:	0.53							
Chi-Squared:	15.08							
Significance Level:	0.01							
Canonical Correlation:	0.69							
Men ≥ 35 years								
VO_2 Max	0.98	Pass	58	(95)	55	(95)	3	(5)
Endurance Grip	0.51	Fail	13	(5)	2	(67)	1	(33)
Flexed Arm Hang	-0.72							
		Total	61		57	(93)	4	(7)
Wilks' Lambda:	0.87							
Chi-Squared:	7.77							
Significance Level:	NS							
Canonical Correlation:	0.36							

Table B5.7 Fifth percentile scores for personnel passing Entrenchment Dig by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	58.8[bd]	42.2[a]	73.0
VO_2 Max	31.1	29.1[a]	31.1[a]
Situps	12.9	10.1	15.2
Pushups	-2.5	-5.8[a]	5.0
Queen's			
ILM	24.0[abcd]	16.9[a]	35.8[d]
Endurance Grip	19.2[abc]	-13.7[d]	59.5[a]
Flexed Arm Hang	-5.5[ab]	-10.0[a]	2.9[a]

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis.

1986), the value for women <35 years was, again, very high as noted consistently through section B in this Report (i.e., at the 65th %ile according to national norms, Reid & Thomson, 1985: p.129).

3. In Table B5.6 minimum pushups for both groups of women (again) produced negative values; as argued earlier in this Report, the drastic change in pushup technique for the present MPFS phase was felt responsible for this spurious finding.

4. Minimum pushups for men ≥35 years was also low, less than one half of their established MPFS of 14 (Stevenson et al., 1986), and particularly low according to Canadian norms, ≤10th %ile (Reid & Thomson, 1985: p.127).

Table B5.7 also summarizes the findings of the earlier analyses carried out on subjects' box-hole dig data by means of superscripts for fitness variables and the relationship to task performance. In only five instances were EXPRES variables found significantly related to performance (see upper half of Table B5.7). By contrast, all three laboratory tests were identified as significant variables in task performance at least once, but, again, compared to similar analyses carried out in the other B sections of this Report a substantial number of inconsistencies both across groups and within individual groups were noted; as well, Phase in three instances produced negative values.

B5.4.7 Impact of Passing and Failing

In Table B5.8, the fitness scores of the subjects passing the box-hole dig are compared to failing subjects' scores: the individual averages for 'passers' versus 'failers' on each EXPRES and laboratory test are compared by Student t-test (with significance accepted at the 0.01 level of confidence in this instance only). For women <35 years, 4 (of 7) comparisons proved significantly different: on all three laboratory tests as well as the passer's maximal grip strength were greater ($p<0.01$). Otherwise, for subjects

Table B5.8 EXPRES and Laboratory Fitness Scores of 'passers' vs 'failers' on the Entrenchment Dig Task.

Variable		Women < 35 Pass		Women < 35 Fail	Women ≥ 35 Pass	Women ≥ 35 Fail	Men ≥ 35 Pass	Men ≥ 35 Fail
EXPRES								
Max Grip	*M*	75.7	*	69.0	62.0	53.5	109.6	106.7
	SD	(10.3)		(11.6)	(12.1)	(8.3)	(22.4)	(5.1)
VO_2 Max	*M*	37.3		36.3	34.2	31.9	41.0	34.1
	SD	(3.6)		(3.6)	(3.2)	(3.1)	6.0	4.6
Situp	*M*	34.2		30.1	25.8	22.0	31.8	28.3
	SD	(13.0)		(9.0)	(9.6)	(9.4)	10.2	2.9
Pushup	*M*	20.4		15.0	11.1	6.1	27.4	20.7
	SD	(14.0)		(7.2)	(10.3)	(3.8)	13.7	10.1
Queen's								
ILM	*M*	32.6	*	27.7	27.2	25.7	52.5	50.0
	SD	(5.3)		(4.2)	(6.3)	(3.6)	10.2	0.0
Endurance Grip	*M*	97.6	*	56.9	105.9	65.0	236.5	126.0
	SD	(47.8)		(29.9)	(72.9)	(27.2)	(107.9)	(70.8)
Flexed Arm Hang	*M*	24.9	*	11.6	11.6	10.9	30.3	31.9
	SD	(18.6)		(10.1)	(13.2)	(15.1)	(16.7)	(19.8)

Note. * Reliable difference ($p < .01$) between passing and failing group means.

≥35 years in the present study, both the men and women, not only were differences between passers and failers not significant but in several instances averages were either numerically equal or failers' average proved the higher value.

Table B5.9 was developed to determine the impact of being correctly classified by EXPRES based on results of the entrenchment dig. Overall 75.8% were correctly classified by the standards for this task. The number of subjects who would have failed EXPRES but passed the task was 11.4% of the total. These results indicated that higher than anticipated 5% would have been falsely classified for sanctions by EXPRES scores.

B5.5 Interpretation

Results from the present study were very similar to those from Phase II when the indoor, box-hole dig was first employed (Stevenson et al., 1986). Both groups of subjects ≥35 years on average required only 42 additional seconds to complete their digs: men ≥35 years required 6.8±2.2 min compared to 6.1±1.9 min in Phase II, while women ≥35 years required 10.5±3.0 min in the present study compared to 9.8±3.1 min in 1986. On the other hand, in both Phases II and III the time required by women <35 years for completion of their digs was almost identical: 8.3±2.2 min in the present study versus 8.5±2.2 min in Phase II. Overall, 63% of the women <35 years in the present study bettered the established (i.e., by Phase II) time criterion of 510 seconds (8.5 min) for the redesigned entrenchment task. For older subjects 61% of women ≥ and 95% of men ≥ bettered the criteria. In Phase II according to this time criterion, 75% of younger subjects had 'passed'.

Many of the subjects ≥35 years appeared capable of digging at faster rates but were prevented from doing so because of their heart rate monitoring. In both years, all subjects ≥35 years, men and women, had to be paced at least

Table B5.9 Impact of fitness standards on classification by pass/fail status for Entrenchment Dig task.

Fitness Test Performance	Entrenchment Dig Task Performance			
	Correctly Classified		Incorrectly Classified	
	(no)	(%)	(no)	(%)
Pass EXPRES	97	65.1	19	12.8
Fail (1 or more)	16	10.7	17	11.4
Total	113	75.8	36	24.2

once, and the majority several times, throughout their digs when heart rate response surpassed 90% of predicted maximum. The intensity of this redesigned dig task was maximal and as such, especially over the first portion of the dig. Subjects had to settle into a controlled rate of digging.

To compare 90% restricted task to unrestricted tasks for subjects ≥, 16 men and 3 women repeated the entrenchment dig (see Table B5.5). Men ≥35 improved their dig times by 36.3% and women ≥35 by 31.0% when heart rate restrictions were removed. Unfortunately the age adjusted heart rate restriction did not identify which subjects had higher maxima and thus who was restricted most severely. An interesting observation occurred when the 16 men were divided into two groups: those subjects who completed the task within one minute of the restricted time, and those who finished in greater than one minute of restricted time. The eight subjects with no improvement in task time (-20 seconds) showed an accurate 90% prediction of their true heart rate (Table B5.5). However with eight subjects who improved their performance significantly (mean task time improvement of 4 minutes) the heart rate restriction was 13 beats under the actual 90% restricted level. In other words these individuals were working at about 80% of their true maximal heart rate. The only way to identify these subjects would be a maximal aerobic test or unrestricted tasks under medical supervision. Based on recommended safety guidelines, these restrictions should not be removed unless CF personnel are subject to sanctions; in which case proper medical supervision must be present during maximal effort testing.

As noted in an earlier Report (Stevenson et al., 1986) comparing actual field digging (in Phase I) versus indoor box-hole digging (Phases II and III), technique was substantially altered. Outdoors, digging through solid, virgin soil the lower body was used much more both for forcing the spade through the ground, then to loosen and lift each shovel full, while the box-hole technique employed the shoulders and back almost exclu even though subjects were instructed in the use of the lower body to assist their digging. Thus, the intensity of working was significantly increased during the box-hole test, as subjects realized that this task did not require the better part of one hour to complete and, therefore, relaxed their self-governor which 'paced' their digging rate outdoors at two-thirds capacity throughout the field dig (Morrissey et al., 1983; Stevenson et al., 1985). Finally, the present box-hole protocol possessed several inherent advantages over actual digging in the field and from results from Phases I and II appeared more reliable and objective as well as safer because subjects were monitored continuously and one-at-a-time. However, some question still remained whether the box-hole dig was prolonged enough; and the intent of the original CF task guidelines and criterion time (i.e., 45 min) was very clear in this regard. On the other hand, results from both Phase II and the present study have substantiated that pacing subjects ≥35 years of age did not adversely effect their dig times, and that there was indeed an inherent, submaximal quality built into the present protocol. DCIEM and ranking CF personnel will, therefore, have to decide whether to establish the box-hole dig in its present format or enlarge the size of the box structure so that the task does require more prolonged work.. However the present investigators believe that the latter modification is not expressly needed at the present time.

Compared to earlier MPFS results, univariant analyses in the present study revealed surprisingly similar trends even though in Phase I after one hour of digging completion times were estimated, in the interests of expediency, for those subjects who had not yet finished digging a regulation entrenchment. First, in all three MPFS studies only a sparse number of significant correlations coefficients were found. Second, for women <35 years their maximal grip in Phase I, and ILM lift in Phase II, were significantly correlated with each groups' dig performances; and in the present study, for the women <35 years (i.e., again 'repeaters' for a third time) both ILM and endurance grip were the only significant r-values found. Third, the vast majority of coefficients for all groups in all Phase phases have always appeared as negatives again substantiating that, as on <u>every</u> common military task, an underlying relationship exists between physical fitness and task performance, specifically on this task between subjects' completion times for the box-hole dig and grip and ILM strength tests. Finally, results of our additional univariant analyses, first attempted in Phase II, correlating subjects' shoveling rates with prolonged digging and performance drop-off again proved futile; so much so that for this Final Report these parameter (though recorded, see protocol section B5.3) have not been reported.

In contrast with these results from univariant analysis, through the three phases of Phase our multivariant analyses have not appreciably improved the predictive value of EXPRES or the laboratory tests in evaluating subject performance on the entrenchment dig because of a lack of consistency in the variables identified by each study. For example, compare the distinct sets of performance predictors identified through multiple regression analysis over the MPFS series for woman <35 years (Stevenson et al., 1985 & 1986): in Phase I, EXPRES pushups and grip strength were identified as significant ($p<0.001$) predictor variables; from Phase II, leg power (as measured by the Wingate ergometer test) and flexed arm hang-time were identified; and in the present study ILM score and grip strength appeared in their prediction equation. Further, in Phase I no female bettered the task criterion time, with 13 of the subjects unable to complete their digs because of compacted soil conditions in the field, yet the predictor variables together accounted for 82% of the variance in this rather dubious performance. Then, with the protocol considerably improved for Phases II and III, two sets of 2 (different) predictors were found each year, each set accounting for only 29% and 38% (respectively) of the variance in these subjects' rather commendable performances. Similarly, for men ≥35 years, both in Phase II and the present study, no significant predictor variables have even appeared in their regression equations. And earlier findings of our multiple regression analyses for men <35 years (Stevenson et al., 1985 & 1986) only abetted this pattern of inconsistency: arm ergometry, then aerobic capacity, were identified as significant predictors in Phase I and II (respectively), but accounted for only small portions of the variance in either study. On the other hand, blocked regression analyses have generally confirmed the findings from univariant analyses, that strength-endurance was the most important fitness component in digging performance. For the women <35 years in both Phase II and the present study, strength-endurance appeared as the only significant ($p<0.001$) component, accounting for 0.25 and 0.40 of the change in R^2 each of these years. This was also found to be the case for men <35 years (in Phase II only) where strength-endurance accounted for 24% of the variance, however in both our '86 study and the present one for men ≥35 years a significant fitness component did not appear. Finally, over our three Phase studies discriminant function analysis has only produced one significant function overall - in the present study, for women <35 years; otherwise, results of this multivariant analysis have also proven only tentative at best.

When the fifth percentile scores were determined for the entrenchment task, the variables which underlied task performance differed for all three groups (Table B5.6). For younger women maximal grip score and the additional laboratory tests were related to performance. For older women three of the four EXPRES and all additional laboratory tests were of note. For men ≥35 only oxygen consumption from EXPRES and the additional tests had significant relationships. Once again these factors point out the differences in groups which force separate EXPRES standards despite a common task performance criteria. However as with other tasks, the pushup scores for women did not provide suitable data to determine a standard.

B5.6 Conclusions

This subset of EXPRES Phase variables proved to be of limited value as discriminators of performance on the box-hole dig task. However, the additional laboratory tests improved performance prediction considerably particularly for women <35 years, but this was definitely not the case for either the men or the women ≥35 years. Therefore, the conclusions to be drawn concerning task performance are limited by the lack of definitive statistical relationships between fitness and performance.

1. These data suggest that a relationship exists between one's fitness (as measured by our laboratory tests) and box-hole dig performance in that 8% to 38% of the variance in performance scores can be explained. However as with previous studies results showed that it was not possible to predict performance on the basis of general fitness parameters.
2. Based on a substudy of 16 men and 3 women, the adjustment for 90% restricted task performance be set at 32% for men or women equal to or greater than thirty five years of age.
3. Because of extenuating circumstances (discussed in section B5.5) specific minimum values in this subset should be disregarded, in particular Phase pushups for women.

More generally, the investigators recommend that the box-hole dig protocol and equipment superstructure be considered as the standardized entrenchment dig task, and that 510 seconds (8.5 min) for subjects <35 years and 673 seconds (11.2 minutes) for subjects ≥35 years be the criterion time for completion of this protocol. This suggestion is based on the fact that the revised entrenchment dig task demonstrated a reliable task protocol.

B5.7 Recommendations

The entrenchment dig was selected as one of the test battery items in that it was one of the most physically demanding tasks within the designated list of Seven Common Tasks for CF personnel (excluding NBCW clothing which would raise the physiological requirements an undetermined amount). The revised task protocol did standardize the amount of work required for all subjects while allowing the subjects to take varying shovel loads. This permitted individual differences in technique, and thus subjects could self-optimize their approach to the task. Unfortunately it was evident from observation that some subjects, primarily females, had inadequate training in this task. Hence the following recommendation is made.

1. Subjects who are asked to perform a task in which they have minimal experience be given an opportunity to train prior to any career based testing situation.

SECTION B6

SANDBAG CARRY TASK ANALYSIS

SECTION B6

SANDBAG CARRY TASK ANALYSIS

B6.1 Introduction

The CF's lift-and-carry task was first studied by the present investigators during our preliminary testing conducted prior to Phase I (see Appendix D, Stevenson et al., 1985). As defined by the CF initially, this task allowed 10 minutes for the subject to move (i.e., lift, carry, then set down) a total of eight, 50-pound sandbags a distance of 50 m. During our preliminary work in the spring of 1985, the male CF personnel (n=12) completed this task in 5.3±0.2 minutes, the female personnel (n=7) in 7.4±1.4 minutes, with only one subject just marginally failing to finish within the 10-minute time period allowed. Even though these subjects' heart rate response upon completing the task were near-maximal (on that occasion averaging 174±15 beats per minute for both groups, males and females), this task was selected out of the Phase I battery because, with such a high success ratio and uniform physiological response, its potential to discriminate between subjects appeared limited.

As a comprise to complete removal of the task in for Phase II the task was modified slightly and renamed the Sandbag Carry: its objective became the total number of 20 kg sandbags that could be carried the 50 m distance (and set down) within 10 minutes (this total time being retained as the duration of the revised task). Using this revised task definition it would be possible to derive a profile of the population on this task from which time-based definition of sand bag carry could be derived if needed.

When extended for the full 10 minutes this modified version proved grueling for subjects to complete (Stevenson et al., 1986). Therefore subjects ≥35 years of age, whose heart rates were not permitted to rise above

90% of maximum and were 'paced' through several of the common military tasks, did not even attempt the sandbag carry during Phase II. As a consequence, a subset of MPFS requirements was not calculated from our 1986 results, even for subjects <35 years of age, for two reasons. First, the lack of any definite statistical relationship was compounded by, second, the small number of participants upon which 'passing' would be determined. MPFS requirements have always been determined from a data base of <u>at least</u> 100 subjects (then derived according to the 'minimum fitness' of the 75% who 'passed') and always based upon much stronger statistical inferences than emerged from Phase II analyses. Therefore, the inclusion of the sandbag carry in the present phase, Phase III, quite literally, represents a recommencement for this task in the MPFS battery.

<u>B6.2 Task Rationale</u>

The protocol established for Phase II (see Appendix C, Stevenson et al., 1986) retained the intent of the original CF task guidelines, that of simulating an emergency situation where sandbags were required at a site 50 m away for purposes of fortification or flood control, while prolonging the test a more realistic length of time. In comparing the results from preliminary testing in 1985 where a standard number of sandbags were handles (i.e., 8 bags only) with Phase II results, several women and men <35 years actually doubled that number of bags carried (Stevenson et al., 1986). Optimally, horizontal load carrying up to 35% of body weight can be performed for prolonged periods employing the upper body musculature (Pandoff et al., 1977; Legg & Mahanty, 1985); physiologically, a work rate of this magnitude elicits a response <50% of maximal aerobic capacity (Myles & Saunders, 1979), expending approximately 400 - 500 watts /per hour. Forced to carry relatively heavier loads however, as lighter subjects in the present study were forced to do (i.e., the 20 kg bags were >35% of their body weight), or attempting to run with this optimal load as some subjects in Phase II attempted, the rate of working actually declines disproportionately as the physiological cost creeps above that which can be sustained for lengthy periods (Snook et al., 1970; Snook & Ciricello, 1974). Moreover, there were interactions with elevated environmental temperatures and humidity, as experienced over the summer months in central Canada, that can have a further detrimental effect upon this 'trade-off' - the magnitude of the submaximal loading versus its physiological costs (Snook & Ciricello, 1974).

Compounding this rather delicate balance, there did not appear to be a single best-method for load carrying by upper body musculature, however some basic principles of carriage were observed in order to minimize the physiological and muscular stress (Legg & Mahanty, 1985). Foremost, the load was located as close to the trunk as possible; that is, as the load's centre of gravity was located closer to the body's centre of gravity both antero-posterior and lateral stability were improved (Perrynowski et al., 1981). Additionally, the larger muscles of the torso should bear most of the weight, rather than the smaller muscles of the hands and arms which fatigue more quickly (Legg, 1985). Finally, anthropometric factors such as height, longer reach, etc. can influence energy expenditure during intermittent load carriage (i.e., lift /carry /set-down performed repetitively) more than subject age or gender (Peacock, 1980). Therefore, to optimize conditions for carrying the 20 kg bags various methods for lifting the sandbags, then carriage through the 50 m course to set-down, were taught to the present subjects (see Appendix C for details); and within these delimitations subjects were permitted to employ self-selected pickup and carriage techniques, determined individually after several practice trials.

B6.3 Task Protocol

The sandbag carry simulated an emergency situation where 20 kg bags full of sand had to be lifted, carried a distance of 50 m, then set down in an orderly fashion, as one would if building a temporary dike or fortification. To accomplish this, a 50 m course was marked off by piling a number of 20 kg sandbags (i.e., up to 10 bags) at either end of the 50 m, then placing four plastic cones at 10 m intervals in a straight line between these end piles. This layout allowed two CF personnel to perform the sandbag carry simultaneously: one subject starting from one end of the course moving those sandbags to the other end, as the second subject performed exactly the opposite. If the two personnel performing in this manner were of equal strength and stamina, often the net movement of sandbags at the end of the 10-minute test period would be no more than 2 or 3 sandbags; on the other hand, if the two subjects were not physically matched, often part way through the test a laboratory tester would have to even up the number of sandbags in the end piles as the physically superior personnel lapped the second subject. In addition, at each end of the course a laboratory tester monitored the progress of the subject who started from that end.

On the command "start", as quickly as possible each subject lifted the first sandbag and carried it along the track to the opposite end, set the bag down (orderly, and in the designated location), then returned to their starting pile to pick up the next sandbag; continuing this procedure was repeated, moving as many bags as possible in the 10-minute test period. On the command "stop" at the end of 10 minutes, supervising testers recorded the subject's progress at that point through the course, to the nearest 10-metre distance.

Prior to testing, subjects were given detailed instruction on correct technique of lifting a sandbag, four optimal methods of carriage, as well as techniques for setting it down. Subjects then were given as much time as required to practice these techniques to determine the most comfortable and efficient methods to use for themselves individually. Finally, prior to actually commencing the task, each subject performed an active, supervised warm-up (see Appendix F for details).

B6.4 Results

B6.4.1 Descriptive Results

In Table B6.1, results of subjects' sandbag carry are presented. The women <35 years and men ≥35 years (all of whom were 'paced' during the test) moved the same number of sandbags, 12.2±2.0 and 12.1±2.6 bags (respectively), while the women ≥35 years (and also paced) carried only 9.5±1.4 sandbags across the 50 m course in the 10 minute period allowed. In contrast subjects' individual data between the two former groups, both their ranges and the overlap between individual subjects' scores were (almost) identical as well: the fastest woman <35 years carried 18 sandbags, the fastest man ≥35 moved 19; the slowest subjects in each group (respectively) carried only 7 and 8 bags; and matching the 58 and 62 subjects in each group on an individual basis, literally, scores could be paired their distributions were so similar. On the other hand, for the women ≥35 years, their scores were bunched together: for the 28 subjects in this group the distribution (of total sandbags carried) all fell within the range of 8 to 12 bags.

B6.4.2 Simple Correlations

Table B6.2 presents correlation analyses of EXPRES and laboratory test variables in relation to the total number of sandbags carried. For men ≥35 years, 4 (of 7) fitness-related coefficients were found to be significant ($p<0.001$), with the highest positive r-value found in the present study (i.e., through sections A or B) associated with their aerobic capacity (see lower

Table B6.1 Summary of Sandbag Carry Performance Scores of the Sample by Age Group and Sex.

	Total Bags Carried
<u>Women < 35 years</u>	
n= 58	
Mean	12.2
SD	2.0
(min-max)	(7-18)
<u>Women ≥ 35 years</u>	
n= 28	
Mean	9.5
SD	1.4
(min-max)	(8-12)
<u>Men ≥ 35 years</u>	
n= 62	
Mean	12.1
SD	2.6
(min-max)	(8-19)

Table B6.2 Correlations Between Sandbag Carry Performance Measures and Fitness Parameters by Sex and Age Levels.

	Women <35	Women ≥35	Men ≥35
Anthropometry			
Age	-.24	.05	-.34
Height	.15	.32	.27
Weight	-.05	.06	.04
Muscular Strength and Endurance			
Situp	.42	.21	.48*
Pushup	.43	.08	.53*
Combined Grip	.39	.42	-.02
Endurance Grip	.24	.48	.45*
Flexed Arm Hang	.53*	.20	.42
Maximum ILM to Full Extension	.50*	.20	.42
Aerobic Capacity			
Step test	.42	.56	.62*

Note * $p<.001$.

right-hand corner of Table B6.2). Otherwise for the female subjects, both women <35 and $\geq$35 years, only 2 (of 14) fitness-related coefficients were significant; as well, for the women $\geq$35 years, of particular note was the r-value associated with their aerobic capacity, while non-significant (at the 0.001 level of confidence) it was nevertheless the second highest, positive r-value found in the present study. In fact, Table B6.2 is the only table of r-values presented in Section B where the large majority of coefficients did not appear as negative values: in point of fact, all but one fitness-related coefficients were positive owing to the fact that in this task a higher value represented a better performance.

B6.4.3 Stepwise Regressions

Results of stepwise regression analyses of the total number of sandbags moved on EXPRES and laboratory test variables are shown in Table B6.3. Examining the three groups of subjects, overall four discrete fitness variables were identified; and in each group's regression equation a unique combination of three (of these 4) variables appeared. On the other hand, each group's regression equation while providing significance at the (accepted) 0.001 level, accounted for changes in R^2 ranging from 0.38 (for women <35 years) to 0.61 (for the women $\geq$35 years).

In Table B6.4, results of regressing the total number of sandbags moved on EXPRES and laboratory scores blocked for fitness components are presented. For women <35 years, the only significant ($p<0.001$) block of variables was that of strength-endurance, evidencing changes in R^2 of 0.35. For the men $\geq$35 years, anthropometric variables provided the only block significant at the 0.001 level, which accounted for changes in R^2 of 0.30. On the other hand, for the women $\geq$35 years no significant blocks appeared.

Table B6.3 Stepwise Regression of Sandbag Carry total number of cycles on fitness parameters by sex and age level.

Variables in Equation	B	SE B	Mult. R.	R^2	F	p
Women < 35 years						
Constant	2.21	2.81				
Flexed Arm Hang	.03	.02	.48	.23	15.87	.001
ILM	.13	.04	.57	.32	12.07	.001
VO_2 Max	.15	.07	.62	.38	10.32	.001
Women ≥ 35 years						
Constant	.28	2.14				
VO_2 Max	.24	.06	.57	.32	9.99	.01
Endurance Grip	.02	.004	.72	.52	10.81	.001
Flexed Arm Hang	-.05	.02	.78	.61	9.89	.001
Men ≥ 35 years						
Constant	-2.18	1.97				
VO_2 Max	.23	.04	.61	.36	32.50	.001
ILM	.07	.03	.71	.50	27.48	.001
Endurance Grip	.01	.002	.74	.54	21.20	.001

Table B6.4 Sandbag Carry total number of cycles regressed on EXPRES and other laboratory tests blocked for fitness components

Block	R^2 Eqn.	F Eqn.	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	.11	1.87	NS	.11	1.87	NS
Strength and Endurance	.46	3.90	.001	.35	4.50	.001
Aerobic Capacity	.50	3.94	.001	.35	2.76	NS
Women ≥ 35 years						
Anthropometric	.07	.44	NS	.07	.44	NS
Strength and Endurance	.38	.76	NS	.31	.93	NS
Aerobic Capacity	.75	3.03	.05	.37	14.88	.01
Men ≥ 35 years						
Anthropometric	.30	7.62	.001	.30	7.62	.001
Strength and Endurance	.54	6.16	.001	.24	4.10	.01
Aerobic Capacity	.61	7.14	.001	.07	7.87	.01

B6.4.4 Criteria for Passing the Task

The sand bag carry involved only 18 women <35 and 48 men <35 years of age in Phase II of the study. For women, the average total number of sand bags moved was 13.1 $\pm$1.4 with a range from 10 to 15 bags. For men a mean score of 17.1 $\pm$1.8 resulted in Phase II. In order to establish a fair 75th percentile score from this sample, 3 sets of random samples of 18 men were selected, and averaged to pool with the data for the 18 women. The 75th percentile fell at 12 sandbags for younger subjects. With the 32% adjustment criteria for heart rate restraint, a passing criteria of 9 sand bags was established for $\geq$35 year old subjects. This value was slightly less than the fifty percent of the older women who would have passed and slightly more than 85% of the older men who would have passed the task criteria.

B6.4.5 Discriminant Analysis

A similar pattern was also found in discriminant analyses (using a stepwise procedure, Table B6.5) as established in the stepwise regressions. The function determined for women <35 years included the same three variable, ILM, VO_2 Max and flexed arm hang (see multiple regression above), but correctly classified only 66% of these subjects, whereas the functions for both groups of subjects $\geq$35 years containing additional variables but did not improve prediction. In the case of the women $\geq$35 years a greater percentage of these subjects were correctly classified (75%), however for older men only 47% were correctly classified with 53% incorrectly classified as failers when they would have passed. B6.4.6 Fifth Percentile of Passing Group

In Table B6.6, the PASSERS within the individual groups (i.e., only the subjects bettering the pass criterion of 12 and 9 sandbags moved in the 10-minute test period for young and older respectively) are profiled according to minimum EXPRES and laboratory test scores. Although this was the first time

Table B6.5 Discriminant analysis and classification results by EXPRES and Queen's variables in groups defined by Sandbag Carry pass fail status.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	Performance %	Predicted Performance Correctly Classified n	Predicted Performance Correctly Classified %	Predicted Performance Incorrectly Classified n	Predicted Performance Incorrectly Classified %
Women < 35 years								
VO_2 Max	0.37	Pass	29	(50)	11	(38)	18	(62)
ILM	0.47	Fail	29	(50)	27	(93)	2	(7)
Flexed Arm Hang	0.60							
		Total	58		38	(66)	20	(34)
Wilks' Lambda:	0.72							
Chi-Squared:	18.28							
Significance Level:	0.001							
Canonical Correlation:	0.53							
Women ≥ 35 years								
VO_2 Max	1.04	Pass	16	(53)	10	(63)	6	(38)
Max Grip	-0.79	Fail	12	(43)	11	(92)	1	(8)
Situps	-0.55							
Pushups	-0.72							
Endurance Grip	2.29							
Flexed Arm Hang	-1.15							
		Total	28		21	(75)	7	(25)
Wilks' Lambda:	0.42							
Chi-Squared:	19.46							
Significance Level:	0.01							
Canonical Correlation:	0.76							
Men ≥ 35 years								
Endurance Grip	0.82	Pass	55	(92)	23	(42)	32	(58)
VO_2 Max	0.48	Fail	5	(8)	5	(100)	0	(0)
		Total	60		28	(47)	32	(53)
Wilks' Lambda:	0.86							
Chi-Squared:	8.31							
Significance Level:	0.05							
Canonical Correlation:	0.37							

Table B6.6 Fifth percentile scores for personnel passing Sandbag Carry by sex and age level.

Variables	Women < 35	Women ≥ 35	Men ≥ 35
EXPRES			
Maximum Grip	57.0	41.5[a]	72.7
VO_2 Max	32.0[abd]	29.1[ad]	31.3[acd]
Situps	15.1[b]	7.4[a]	15.3[c]
Pushups	0.42[b]	-5.7[a]	7.1[c]
Queen's			
ILM	23.0[abcd]	19.1	36.4[d]
Endurance Grip	13.8	-10.4[ad]	72.3[abcd]
Flexed Arm Hang	0.02[abcd]	-11.3[ad]	3.6

Note. a=Variable identified in discriminant analysis

b=Reliable difference exists between means of passing and failing groups in predicted direction

c=Reliable relationship between fitness variable and task performance indicated by simple correlation

d=Variable identified in stepwise multiple regression analysis

that an MPFS subset had been determined for the sandbag carry task, these values incorporated similar minimum EXPRES values (and in three instances identical minimum values) as determined in the preceding sections for the low high crawl, both evacuation tasks and the box-hole dig, sections B2.5, B3.5 and 4.5, and B5.5 (respectively).

1. MPFS requirements for all three groups of subjects in the present study for VO_2 Max were both comparable to established MPFS standards (Stevenson et al., 1986) and compatible with Canadian norms (i.e., ≤30th %ile, according to sex and age grouping: Reid & Thomson, 1985: p.142).

2. Similarly, MPFS sit-up requirements for women <35 years and men ≥35 were comparable to established MPFS standards (Stevenson et al., 1986), however, minimum sit-ups for women ≥35 years were low both in comparison to other minima in Section B of this Report as well as national norms (i.e., 5th-10th %iles, Reid & Thomson, 1985: p. 126).

3. On the other hand, minimum grip for both women and men ≥35 years were in close agreement with MPFS values determined in earlier studies (Stevenson et al., 1985 & 1986) as well as on the other tasks in the present study. However, the minimum grip for women <35 years was, again, high as noted consistently throughout Section B in this Report (i.e., >60th %ile according to Canadian norms; Reid & Thomson, 1985: p. 129).

4. In Table B6.6 minimum pushups for both groups of women were again extremely low: for women <35 years MPFS was less than one pushup; for women ≥35 years their determined minimum produced a <u>negative</u> value. As argued earlier in the Report, the drastic change in pushup technique for the present MPFS phase was felt responsible for this spurious finding.

5. Minimum pushups for men $\geq$35 years was also low, one-half of their established MPFS of 14 (Stevenson et al., 1986), and particularly low according to Canadian norms (i.e., $\leq$10th %ile; Reid & Thomson, 1985: p. 127) and insight of the fact that, as a group, these men scored particularly high on EXPRES pushups (i.e., 27.1$\pm$13.5 pushups, above the 75th %ile). In addition it is a result of an altered strategy of determining the pass/fail cut off.

Table B6.6 also summarizes the findings of the earlier analyses carried out on subjects' sandbag carry data throughout this section (see Table footnotes) to indicate the relative importance of fitness variables to each of the groups in terms of evaluating task performance. In all but two instances EXPRES variables were found significantly ($p<0.001$) related to performance. And for the first time in either Phase II or the present study one test variable (i.e., VO_2 Max) was identified across all groups in two different analyses (i.e., by discriminant and multiple regression analysis). Further, in all but three instances the laboratory test variables were found significantly related to performance (see lower half of Table). However, despite these statistical relationships, compared to similar analyses carried out in the other B sections of this Report, a substantial number of inconsistencies both across groups and within individual groups were noted, plus the fact in Table B6.6 that: i)three MPFS minima produced negative values, while ii)three others were unreasonably low (for the particular group of subjects in question).

B6.4.7 Impact of Passing and Failing

In Table B6.7, the fitness scores of the subjects passing the sandbag carry are compared to failing subjects' scores: the individual averages for 'passers' versus 'failers' on each EXPRES and laboratory test are compared by Student t-test (with significance accepted at the 0.01 level of confidence in this instance only). For women <35 years, on 5 (of 7) comparisons the

Table B6.7 EXPRES and Laboratory Fitness Scores of 'passers'vs 'failers' on the Sand bag Carry Task.

Variable		Women < 35 Pass	Women < 35 Fail	Women $\geq$ 35 Pass	Women $\geq$ 35 Fail	Men $\geq$ 35 Pass	Men $\geq$ 35 Fail
EXPRES							
Max Grip	M	75.4	70.6	60.7	55.9	109.6	102.4
	SD	11.2	10.8	11.7	11.0	(22.5)	(6.8)
VO_2 Max	M	38.1	* 35.7	34.2	32.1	40.8	36.1
	SD	(3.7)	(3.1)	3.1	3.2	(5.8)	(5.4)
Situp	M	35.9	* 29.0	24.5	24.1	31.5	28.8
	SD	12.7	9.4	10.4	8.6	(9.9)	(4.4)
Pushup	M	22.4	* 14.3	8.1	10.5	26.6	21.8
	SD	13.4	9.6	8.4	9.1	(11.9)	(8.0)
Queen's							
ILM	M	32.7	* 28.8	26.9	26.3	52.3	48.0
	SD	5.9	4.3	4.7	6.4	(9.7)	(2.7)
Endurance Grip	M	87.4	76.7	108.7	64.7	235.8	* 115.4
	SD	44.9	48.4	72.6	32.3	(99.7)	(49.9)
Flexed Arm Hang	M	27.9	* 11.8	11.2	11.4	31.0	18.9
	SD	17.0	13.6	(13.7)	14.3	(16.7)	(11.9)

Note. * Reliable difference ($p<.01$) between passing and failing group means.

passers' scores proved significantly ($p<0.01$) greater, on 3 EXPRES tests and 2 laboratory tests even though in three cases the actual numerical differences (between passers and failers scores) were not substantial. In fact, for the two other groups of subjects, both men and women ≥35 years, several of the differences between the passing versus failing subgroups were much greater yet of these 14 comparisons only one (i.e., endurance grip for men ≥35 years) proved to be significant ($p<0.01$). On the other hand, in several of these latter comparisons the subgroup averages were (almost) numerically equal, while in two instances failers recorded higher scores (i.e., the women ≥35 years, failers' average pushups and flexed-arm hang time were slightly higher).

In Table B6.8, the proposed EXPRES standards from Table A14 are examined in relationship to correct classification as a passer or failer of the sand bag carry. In total 72.1% were correctly classified with 9.5% incorrectly classified by EXPRES as failing the task. Although 18.4% who failed the task had passing EXPRES scores, this relationship was not controlled by the empirical approach of establishing the criteria based on those subjects who passed the task.

B6.5 Interpretation

Upon examination of all the common military tasks throughout section B, the effects of heart rate monitoring of subjects ≥35 years was shown most acutely in the results of their sandbag carry. In Phase II the women <35 years (n=18) moved a similar number of sandbags as their counterparts carried in the present study: 13.1±1.4 bags in phase II (Stevenson et al., 1986), and 12.2±2.0 bags by the present group of women <35 years. In sharp contrast, in Phase II the men <35 years (who of course were not paced) carried 17.1±1.8 sandbags, with their range of scores being 13 - 21 bags; in the present study

Table B6.8 Impact of fitness standards on classification by pass/fail status for Sand Bag Carry task.

Fitness Test Performance	Sand bag Carry Task Performance			
	Correctly Classified (no)	Correctly Classified (%)	Incorrectly Classified (no)	Incorrectly Classified (%)
Pass EXPRES	87	59.2	27	18.9
Fail (1 or more)	19	12.9	14	9.5
Total	106	72.1	41	27.9

the men ≥35 years moved only 12.1±2.6 sandbags, and while their upper range of scores was similar to last year's results the lower-end distribution of scores showed the effects of pacing: 25% of these subjects, although more than capable of doing so, were restricted to carrying at a rate of only one-bag-per-minute (i.e., 16 men moved ≤10 bags during the 10 min task) pacing retarded their progress to such a degree. And this same effect was even more dramatic comparing the distribution of scores recorded by the women ≥35 years, versus their younger counterparts: literally, the scores for the ≥35 women were all bunched together, i.e., between 8 - 12 sandbags moved, while for every other group that has completed this task - either during preliminary work (Stevenson et al., 1985 & 1986) or in Phase II (Stevenson et al, 1986) - scores have been well spread. It is improbable that a fully functional and healthy CF personnel would move through the sandbag carry course at a rate slower than one bag moved per minute. The ramifications of pacing then on this task was to lump subjects' scores together: that is, if forced to move slow enough all subjects will achieve very similar scores, which was exactly what happened with the women ≥35 years and at least 25% of the men in that age group as well. In turn, this negated the basic concept of MPFS because these subjects were forced into 'minimum' performances.

In both Phase II and the present study univariant analyses correlating subjects' fitness and performance in the sandbag carry have produced the only correlation matrices with a preponderance of positive r-values once again reaffirming the relationship of fitness to task performance. In fact, in Table B6.2a of the Phase II Report (Stevenson et al., 1986: p.177) and Table B6.2 in the last section, of the 45 fitness-related and directly-measured r-values (i.e., discounting all derived coefficients where the sign becomes meaningless) all but two coefficients appeared as positive values. Since the sandbag carry was the only common military task which was not scored according to time (i.e., time was set at 10 min) but rather by the total number of bags moved, again, but in this instance because of the plethora of positive r-values, the underlying relationship between subjects' physical fitness and their performances was apparent: the higher one's fitness scores on the various EXPRES and laboratory tests the greater number of sandbags that subject was capable of moving over the 10-min test period. And this indirect evidence of the efficacious influence which fitness exerts upon task performance was underscored by the unique correlations relating aerobic capacity specifically and the number of sandbags which subjects carried. For subjects <35 years, both in Phase II and the present study, women and men, these r-values were non-significant and ranged between -0.09 and +0.42. On the other hand, for subjects $\geq$35 years both the men and women, r-values relating aerobic capacity and their performances were highly positive (and for the men $\geq$35 significant at the 0.001 level) which was not unexpected because these subjects were closely 'paced': that is, the higher each individuals' aerobic capacity, therefore the faster that person was permitted to move sandbags.

In both Phase II and the present study, multivariant analyses of subjects' sandbag carry data have proven the most meaningful in terms of performance prediction, particularly stepwise multiple regression (compare Tables B6.3 in Stevenson et al., 1986: p.180 and from the last section). For the women and men <35 years, and in both studies, very similar combinations of four specific fitness variables were identified, with all but two of the regression equations being significant at the (accepted) 0.001 level of confidence: endurance grip, flexed arm hang, and VO_2 Max have been the three endurance-related variables consistently identified, with subjects' maximal ILM lift being the fourth variable and strength-related. Surprisingly, however, in our blocked regression analyses (compare Tables B6.4 in Stevenson et al., 1986: p.182 and from the last section) the strength-endurance component has not appeared consistently (i.e., proven significant only once, in the present study for women <35 years), while accounting for a range of R^2 changes (i.e., from 0.11 to 0.54). Further, discriminant analysis (determined only on the present data, not in MPFS II due to insufficient numbers of subjects for meaningful interpretation) produced only one significant function (again for the women <35, $p<0.001$); however, only two-thirds of these subjects were correctly classified by this function which was composed of a specific combination of the (above) fitness variables, weighted accordingly (see Table B6.5). Therefore, considering these results overall (i.e., both the univariant and these multivariant analyses), again a strong conclusion could not be drawn regarding the prediction of subjects sandbag carrying performance from scores on their EXPRES and laboratory tests. On the other hand, these results beg the question: if the subjects ≥35 years, both men and women, had not been paced would the predictive ability of these statistical analyses have been improved? Certainly in the case of aerobic capacity, without 'pacing' the strength of our univariant analysis would have been reduced, based upon results of subjects <35 years from both Phase II and the present study who exhibited lower as well as inconsistent r-values associated with their aerobic capacity scores.

In terms of the fifth percentile of the passing group, (Table B6.6) there were more significant relationships with general fitness variables for this task than any of the other tasks. In particular oxygen consumption was a dominant factor. This could be explained by the fact that the subject usually carried the load on the shoulder or on the chest while walking briskly or jogging with the 20 kg sand bag. Unlike the 40 kg land evacuation task where the small muscle groups in the arms were required to bear the load, the sand bag carry was a total body activity. This resulted in a more global fitness relationship than in other tasks as attested by the fact that 38% to 61% of the variance in test scores was explained (Table B6.3). However, as with all tasks, the differences in group means between passing and failing groups were not often significant. This was due to unexplained variance in the data. None the less only 9.5% would have been incorrectly classified as failing the tasks by the proposed EXPRES minima in Table A14.

B6.6 Conclusions

Based upon our statistical analyses, prediction of subject performance on the sand bag carry was higher for this task than on any of the other common military tasks, despite the fact that 'pacing' of subjects ≥35 years tended to clump these subjects' scores together. On the other hand, this subset of both EXPRES and the laboratory test MPFS variables was not substantially different from minimum values determined on the other common tasks in Section B. Therefore, the conclusions to be drawn concerning task performance are:

1. The statistical relationships found suggest that there was a strong underlying relationship between one's fitness (as measured by both EXPRES and our laboratory tests) and sandbag carry performance in that 38% to 61% of the variance in task performance was explained. As with previous studies, results were consistant in that it was not possible to predict sandbag performance on the basis of general fitness parameters.
2. In this regard, but contrary to our Phase II findings, aerobic capacity, as measured by the EXPRES step test, was judged to be the most important variable.
3. Because of extenuating circumstances (discussed in section B6.5) specific minimum values in this subset should again be disregarded, in particular MPFS pushups for woman.

More generally, the investigators recommend that the sandbag carry protocol be considered for inclusion as the standardized 10 minute lift-and-carry task, and that 12 and 9 sandbags for younger and older subjects respectively be considered as the performance criterion. This suggestions is based on the fact that the sand bag carry has a reliable task protocol.

B6.7 Recommendations

The sand bag carry task was selected and tested in that it was one of the msot demanding tasks within the battery of Seven Common TAsks for CF Personnel (excluding NBCW clothing which would raise the physiological requirements). The task definition was fixed at 20 kg sand bags a 50 m distance and 10 minute time limit with the criterion measure being speed alone. This type of fixed task definition did not permit optimal performance of all subjects. For example the 20 kg load represented 24.9% of the average weight of men in this study (80.3 kg) and 30.8% of the average weight of women (64.9 kg). For optimum performance of all subjects the following recommendation is made:

1. The CF work toward the creation of task definitions which create optimal performance of all personnel thus giving due consideration to ergonomic redesign of tasks. Once the tasks and measurement criteria are optimized then subjects should be screened for adequate performance on the task.

SECTION B7

LIST OF REFERENCES

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SECTION C

ALTERNATE MODEL FOR DETERMINING LIKELIHOOD OF SUCCESS IN TASK PERFORMANCE

ALTERNATE MODEL FOR DETERMINING LIKELIHOOD OF SUCCESS IN TASK PERFORMANCE

C1.1 Introduction

Most approaches to predicting task performance depend on developing a predictive model linking together fitness variables with task performance scores. It is presumed that given the perfect model, fitness measures will accurately predict actual task performance. Two problems face such an approach. First, the nature of the predictive equation is as yet unknown. Second, the measurements used for fitness and task performance have considerable error associated with them. As a result, correlation coefficients for models used in this study and in other similar studies rarely account for more than 60% of the variance amongst the task performance scores.

An alternate approach to interpreting the results of predictive equations is to incorporate the uncertainty of the prediction itself. By this, predictive equations are used to express a likelihood for achieving a task score rather than to predict task score in absolute terms.

C1.2 Theory

The multiple linear regression models with the highest correlation to task performance are shown in Figure C1. Note that different regression equations are required depending upon the age and gender of an individual. The use of different equations reflects the different techniques used by individuals to perform tasks and have been developed from Section A and B of this report.

Within a single age and gender category, five regression equations exist. These predict the performance scores for entrenchment dig, low-high crawl, sea evacuation, land evacuation and sand bag carry. The independent variables used to predict these scores are the EXPRES variables plus the free style ILM

Nomenclature

DIGT Time in minutes to execute entrenchment dig.
CRWLT Time in seconds to execute low-high crawl.
SEAT Time in seconds to execute sea evacuation.
LANDT Time in minutes to execute land evacuation.
SBAG Number of sandbags carried in 10 minute interval.
PUSHUP Number of pushups per *EXPRES* protocol.
SITUP Number of situps per *EXPRES* protocol.
MXGRIP Grip strength (kg) per *EXPRES* protocol.
VO_2MAX Aerobic capacity (ml/kg/min) per *EXPRES* protocol.
ILM ILM score (kg) per freestyle 1.5 m. protocol.
SEE Standard error of the esimate for regression equation.

Males older than 35 years.

DIGT = 11.884 -.022(ILM) + .055(PUSHUP) - .072(SITUP). *SEE = 2.03*
ln(CRWLT) = 6.101 - .021(VO_2MAX) -.016(SITUP). *SEE = 1.37*
SEAT = 72.316 - .340(ILM) - .491(SITUP). *SEE = 12.64*
ln(LANDT) = 3.388 -.007(ILM) - .013(VO_2MAX) - .007(SITUP). *SEE = 1.247*
SBAG = -2.696 + .098(ILM) + .240(VO_2MAX). *SEE = 1.84*

Females younger than 35 years.

DIGT = 17.695 - .199(ILM) -.046(MXGRIP). *SEE = 1.63*
CRWLT = 436.62 -2.799(ILM) - 5.093(VO_2MAX) - .963(PUSHUP). *SEE = 32.60*
SEAT = 394.71 - 7.829(ILM). *SEE = 157.7*
LANDT = 31.439 - .202(ILM) - .260(VO_2MAX) - .096(SITUP). *SEE = 2.46*
SBAG = -1.166 + .108(ILM) + .166(VO_2MAX) + .043(MXGRIP) + .043(PUSHUP). *SEE = 1.57*

Females older than 35 years.

DIGT = 28.905 - .354(VO_2MAX) - .112(MXGRIP). *SEE = 2.43*
CRWLT = 577.62 - 9.717(VO_2MAX) + 2.709(PUSHUP) - 2.750(SITUP). *SEE = 2.429*
ln(SEAT) = 11.268 - .096(VO_2MAX) - .047(MXGRIP). *SEE = 1.93*
LANDT = 48.729 - .497(VO_2MAX) - .276(MXGRIP). *SEE = 3.37*
SBAG = -.806 + .271(VO_2MAX) + .051(MXGRIP). *SEE = 1.08*

Figure C1. Multiple Linear Regression Models for Prediction of Task Performance Based on Age and Gender.

score.

Consider the regression equation for males over 35 required to predict the number of sand bags carried in ten minutes.

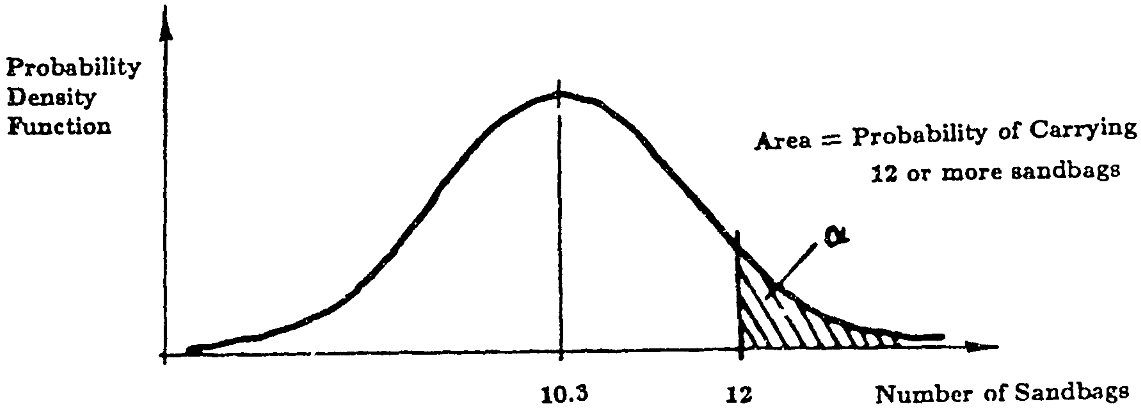
$$SBAG = -2.696 + .098(ILM) + .024(VO_2MAX)$$

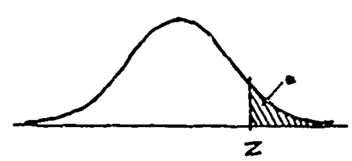
The equation predicts the sand bag performance based on ILM score and aerobic capacity. As shown in Figure C1, the uncertainty associated with the equation is given by the standard error of the estimate (S.E.E.). In this case, the S.E.E. is 1.84 sand bags. One approximation to the distribution of values about the predicted score is to use the S.E.E. in a manner similar to the standard deviation for mean values.

As an example, consider an individual with an ILM score of 48 kg and an aerobic capacity of 36 ml/kg/min. Substitution into the appropriate predictive equation gives a value of 10.6 for the number of carries in a ten minute interval. Using the S.E.E. for this equation (1.84) gives the probability distribution shown in Figure C2. The vertical axis is the probability density and the horizontal axis is the number of sand bags carried. This curve can be used to predict the likelihood of a particular score by computing the area under the function bounded by the target value for the number of sand bags.

To compute the likelihood that this individual will carry a target score of twelve or more sand bags, this value is located on the ordinate of the probability density function. The area under the curve to the right of this value gives the required probability.

The area is computated based on Z-scores. The Z-score is the number of standard deviations a particular value is from the mean of a distribution. In this case, the mean of the distribution is the predicted value (10.6). Thus,





z = 0.76

Area = α ≈ 0.23

α	z	α	z	α	z	α	z	α	z
.50	0.0000	.050	1.6449	.030	1.8808	.020	2.0537	.010	2.3263
.45	0.1257	.048	1.6646	.029	1.8957	.019	2.0749	.009	2.3656
.40	0.2533	.046	1.6849	.028	1.9110	.018	2.0969	.008	2.4089
.35	0.3853	.044	1.7060	.027	1.9268	.017	2.1201	.007	2.4573
.30	0.5244	.042	1.7279	.026	1.9431	.016	2.1444	.006	2.5121
.25	0.6745	.040	1.7507	.025	1.9600	.015	2.1701	.005	2.5758
.20	0.8416	.038	1.7744	.024	1.9774	.014	2.1973	.004	2.6521
.15	1.0364	.036	1.7991	.023	1.9954	.013	2.2262	.003	2.7478
.10	1.2816	.034	1.8250	.022	2.0141	.012	2.2571	.002	2.8782
.05	1.6449	.032	1.8522	.021	2.0335	.011	2.2904	.001	3.0902

Figure C2. Probability Distribution for Sandbag Carry Example. Upper figure is scaled for the example. Lower figure is normalized for a standard deviation of unity.

the target score of twelve sand bags is 1.4 units away from the mean. The Z-score is the ratio of the number of units to the standard error of the estimate. Thus,

$$z = \frac{Units}{S.E.E.} = \frac{1.4}{1.84} = .76$$

The standard statistical table in Figure C2 gives the area to the right of the target score as a fraction of the whole curve. In this case, a value of 0.23 is computed, thus this individual would have a 23% likelihood of achieving a score of twelve or more sand bags in the ten minute interval.

C1.3 Probability Tables

This concept can be logically extended to include other target scores for a particular individual. In theory, one can compute the likelihood of carrying any number of sand bags. Table C1 presents the likelihood of the example individual achieving various numbers of sand bag carries in the 10-minute time interval. Note that the success likelihood is very high for small numbers of sand bags and very low for high numbers of sand bags. By definition, the individual is 50% likely to achieve the predicted score (10.6). That is, the individual is as likely to succeed as fail at this target performance.

Regression equations can be used to cover the probabilities of achieving target scores for all five of the performance tests. This is illustrated conceptually in Figure C3. As input, an individual's EXPRES scores and ILM score are entered. Next, the appropriate regression equation is selected on the basis of age and gender. Finally, the probability tables for each task are produced, which are unique for that individual.

Table C1. Success Probability Table for Sandbag Example.

Target score *Carries*	Success Probability %
7	99
8	88
9	79
10	62
11	41
12	23
13	10
14	3

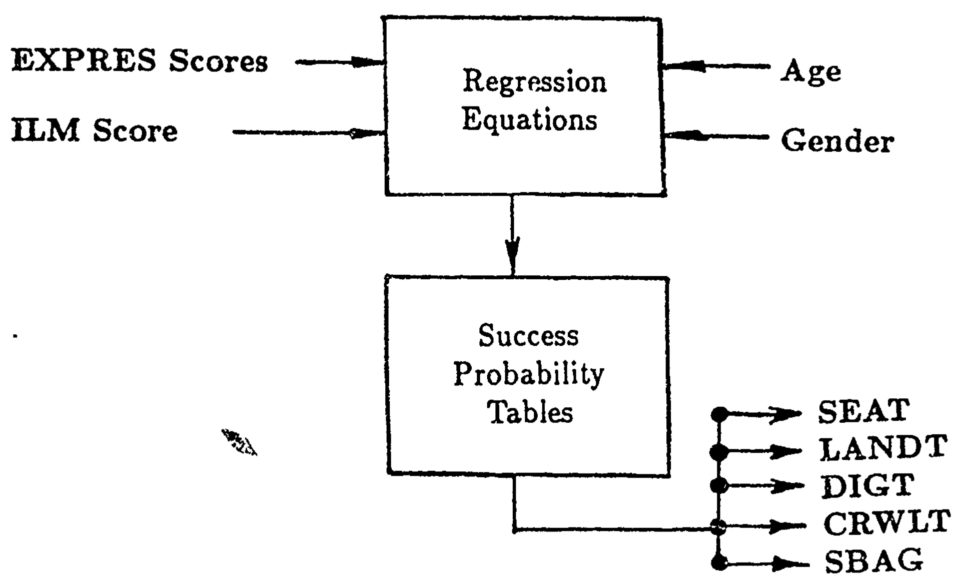


Figure C3. Flowchart for Producing Success Probability Tables.

These tables have the particular advantage of allowing for individual's strengths and weaknesses in various fitness parameters. For example, an individual who is low on an ILM score can compensate by having a higher aerobic capacity and still be able to execute the sand bag carry with reasonable success probability. In addition, the selection of regression equations on the basis of gender and age allow for observed differences in techniques among these groups.

C1.4 Interpretation

The interpretation of probability tables requires some balance between the risk of success based on physical variables alone and the influence of other factors. For example, an individual who has physical fitness parameters indicating a 60% likelihood of success at a particular target performance may generally be unacceptable in certain applications. However, if it is noted that this individual is highly motivated and of considerable experience, one could justify the acceptance of a lower probability value for this individual.

The use of success probability serves as the basis for a reasonable test of suitability. For example, one might consider that a 50% likelihood of success would be a reasonable point to accept performance. This has two benefits. First, it serves as an indicator for an individual who should be examined executing the task as a true test of this person's ability. Second, the probability tables indicate a reasonable expectation of performance for a given individual. This latter aspect is particularly useful if one is to reconsider the design of a particular task to suit a person's ability.

C1.5 Validation

There are several reservations associated with this model. First, the model is based on probability distributions which are difficult to verify using the small sample populations studied. Second, the models are based on theory and not on prevalence or incidence. That is, the probability tables are established on the basis of analytical expressions rather than the observation of success or failure among individuals.

In order to properly validate the probability tables, it would be necessary to compute actuarial data in a manner similar to life expectancy and survivorship. This would require approximately 1,000 individuals in each of the age categories. Given the long term objectives for the acquisition of data regarding fitness and task performance in the CF, such an objective could be met, providing that data were carefully compiled and analyzed.

C1.6 Conclusions

The concept of a probability distribution has been used successfully in other fields and could be used in the CF to assess a person's likelihood of success or failure at a task based on EXPRES and ILM data. This approach would:

1) Allow for individual strengths or weaknesses in various fitness parameters; and
2) Permit the CF to use success probability as the basis for a reasonable test of suitability: (i) it identifies those who should be examined executing the task as a true test of ability and (ii) it indicates reasonable expectations of individuals executing a specific task.

To validate a probability model, the CF would be required to continue testing personnel on tasks and tests until there were sufficient data to develop prevalence and incidence tables. To do this, consideration should be given to transferring the technology of data acquisition to a CF base where trained personnel could process subjects continuously.

APPENDIX A

ORIGINAL SEVEN COMMON TASKS

LIST OF THE SEVEN COMMON TASKS

1. Operate his/her personal weapon

Complete infantry annual weapons test "Shoot to Live", CFP 318 (...) to pass standard.

2. Function effectively in an NBCW environment

In individual protective equipment and using mask and in a high heat environment, perform normal duties for 8 h slowly to meet objective of preventing physical breakdown associated with heat stress and isolation of NBCW posture. (Note, normal duties to be defined).

3. Perform first aid and casualty evacuation

a. Two person team, using a stretcher, will evacuate a normal person (80 kg) across rough terrain a distance of 1 km within 20 min.

b. Two person team will move a stretcher with 80 kg person, while in fire-fighting gear, a horizontal distance of 25 m followed by moving the stretcher up and down one deck in 10 min.

4. Perform fire-fighting duties

In fire-fighting gear and using breathing apparatus and in varying tempuratures, control 50 ft (15 m) of charged hose for 30 min climbing and descending one deck.

5. Execute survival and search and rescue techniques

In environmental clothing, walk at slow speed (80-100 paces per minute over all kinds of terrain for 8 h.

6. Perform general security duties

The following is a verbatim description of "common soldiering tasks" proposed for US infantry (note: mixture of imperial and metric units). These items are tentatively considered representative of security duties.

a. March 8 km (2 h): personnel are placed in march formation, light packs and carrying weapons; they are allowed to establish their own pace while marching on roads over level or slightly rolling terrain.

b. Dig emplacement (45 min): Each person digs a one-man foxhole to a depth of 18 ins in soil of medium firmness with no rocks or large roots using the entrenchment tool. The foxhole is approximately 6 ft long and 2 ft wide.

c. Lift and carry (10 min): The soldier lifts and carries a 50 lb bag of sand for 50 m. The bag is set down and the person moves back to the starting line where the procedure is repeated until 8 bags are moved.

d. Low and high crawl (90 sec): The soldier does the low crawl (all body parts close to the ground) for 30 m, turns 180 degrees and does the high crawl (on hands and knees) for 45 m.

e. Rush (25 sec): The soldier sprints 75 m carrying weapon with t[illegible] intermediate stops of 2 sec each behind cover barriers at [illegible] and [illegible] m [illegible].

7. <u>Live and work in his/her applicable environmental conditio</u>

As for 6, but with NBCW clothing.

APPENDIX B

ETHICS REVIEWS: DOCUMENTATION AND CORRESPONDENCE

A5

School of Physical and Health Education
Queen's University

ETHICS REVIEW PROCEDURE

STAGE 1:
PRELIMINARY REVIEW FORM

NAME OF RESEARCHER: J.M. Stevenson, J.T. Bryant, G.M. Andrew

NAME OF FACULTY SUPERVISOR (if applicant is a student) ____________

TITLE AND PURPOSE OF PROJECT: Minimum Physical Fitness Standards Study: Phase III Development of Fitness Standards for use by the Canadian Forces

BRIEF DESCRIPTION OF PROJECT: This project will upgrade the data aquisition and analysis procedure so that it can be used by military personnel in future phases of the MPFS project.

DESCRIPTION AND SELECTION OF SUBJECTS: The subjects will be 250 CF Personnel aged 18 to 49 years, who are in good health as recommended by CF Medical Personnel.

NATURE OF TESTS EMPLOYED: The tests will be five tasks (Land Stretcher Carry, Shipboard Evacuation, Low High Crawl, Sand Bag Carry and Entrenchment Dig), and four fitness tests (ILM, Grip Endurance, Flexed Arm Hang and Kin/Com).

QUESTION CHECK LIST:

	YES	NO	N/A
1. Is there any physical risk to subjects expected?	X		
2. Is there likely to be any breach in confidentiality?		X	
3. Does the study involve deception of the subject?		X	
4. Is there any subject (physical or psychological) discomfort, embarrassment, or harassment expected?	X		
5. Does the study involve captive or disadvantaged groups, such as prisoners or the mentally handicapped?		X	
6. Does the study involve subjects for whom vicarious consent is needed, i.e., experiments on children with the consent of parents?		X	
7. Does the study involve experimenters who are in a position to unduly influence subjects to participate, such as experiments by professors involving students?		X	
8. Does the study involve a risk to the safety and well-being of the investigator and/or research assistants in regard to possible dangerous behaviour on behalf of the subjects? (i.e. prisoners, patients, etc.)		X	

DATE: ____________

DIRECTOR: ____________

ERGONOMICS RESEARCH LABORATORY

School of Physical and Health Education

Queen's University

Minimum Physical Fitness Standards Study: Phase III

Over the last two years the Queen's Ergonomics Research Laboratory has been working cooperatively with DCIEM and DPERA to develop Minimum Physical Fitness Standards for the Canadian Armed Forces. These standards have been based on seven common military tasks which could occur in cases of emergency and would be required of all CF Personnel regardless of trade, classification, age, or sex.

In 1985, the first year of data acquisition, the specific fitness requirements of seven tasks were investigated. These tasks included three casualty evacuation tasks, an entrenchment dig task, a low high crawl, a sand bag carry and a fire extinguishing task. The ensuing testing over the summer of '85 allowed us to present to the military a preliminary profile of the fitness demands of the tasks and, thus, to tentatively suggest minimum fitness requirements for men.

In the second contract with DCIEM and DPERA in 1986, the Queen's Ergonomics Laboratory created operational definitions for each of the most physically demanding tasks in the test battery. The definitions were designed to develop better control of conditions (i.e., the box dig), create one-person tasks (i.e., the sea and land stretcher carries) and establish consistent task demands (such as, the height barrier for the low high crawl). The data collection for this second phase involved the study of both men and women who were required to complete six of the seven tasks tested the previous summer. Women executing the tasks were almost all under 35 years of age with only a small group of older subjects previewed. Men were studied in two subgroups; namely, under and over 35 years of age.

Queen's has once again been contracted by the military to continue the investigation of the fitness requirements of five of the original seven military tasks. Further research is necessary to ensure a large and representative sample population. As well, research time must be devoted to upgrading the data aquisition and analysis procedure so that it can be implemented by military personnel in future phases of the MPFS project. Therefore, the purpose of the present phase of MPFS is:

1. to validate the minimum physical fitness standard of younger women and older men;
2. to collect preliminary data on older women;
3. to upgrade data aquisition and analysis in preparation for technology transfer, and ;
4. to examine subject safety in execution of these difficult and complex tasks.

Testing Procedures

The Ergonomics Research Laboratory is contracted to conduct this study at Queen's University commencing June 1 1987. Six trained research assistants from our laboratory will carry out the test procedures and protocols at the following (individual) Stations; one morning or one afternoon (i.e., a 3.5 hour period) will be allotted for completion of each Station (see below), with approximately 25 female/or male CF Personnel (i.e., the subjects) being tested to any one station. The stations are:

1. Casualty Evacuations: a stretcher carry with a load of 80 kg over flat terrain for a distance of up to 1 km;
   - up and down a flight of stairs (i.e., shipboard stairs simulated);

2. Entrenchment Dig: Personnel will be asked to dig a foxhole (i.e., foxhole simulation, filled with crushed/powdered rock);
3. Low High Crawl: over flat terrain, first crawling low using 'leopard crawl' technique for 30 m., then on hands and knees for 45 m, while carrying a rifle (i.e., simulated, made entirely of wood and equal in weight to the M16 rifle);

4. Sand Bag Carry: over a 10-minute test period Personnel will be asked to carry sand bags (weighing 20 kg, individually one-at-a-time) a distance of 50 m, setting each bag down then returning for the next bag and repeating this procedure;

5. Queen's Station. At the contractor's request and based upon test results in 1986, the following tests will again be conducted (termed 'Queen's Station'): grip endurance, flexed arm hang and lifting tests using the Forces' own testing device, The Incremental Lifting Machine (ILM). Some subjects will be required to perform maximal arm extension and arm flexion Kin/Com tests under both isometric and isokinetic conditions.

Informing Subjects and Subjects' Participation

250 CF Personnel in all, aged 18 to 49 years, who are in good health as recommended by CF Medical Personnel will be tested. At each Station and prior to any testing, the following procedures will be strictly adhered to:

PRELIMINARIES

i) First, a detailed verbal explanation of that task will be given; as well, each subject will be given, prior to the testing sequence, a written explanation of that task.

ii) Second, a thorough task demonstration will be performed by the

Station Testers, this will both detail and visually show the complete task protocol, highlight the skill, and the means of scoring (i.e., completion time, number of repetitions, etc.).

iii) Third, throughout both i) and iii) (above), questions and personal concerns on the part of the subjects will be encouraged; following task demonstration a formal question-and-answer period will be conducted to ensure that all subjects are throughly informed of both the task and test expectations.

iv) Finally, statements and subject information relating to the following will be re-emphasized by the Station Testers:

a) the safety procedures specifically related to that Station; any applicable, and more general, safety procedure (see next section);

b) statement re-emphasizing that should any subject wish to discontinue that particular task at any point he/she should feel free to do so immediately.

WARM-UP/PERFORMANCE/WARM-DOWN

i) First, on an individual basis, each subject will be conducted through the warm-up procedures for that Station by a Tester; in general, these warm-up procedures will be commenced 10-15 minutes prior to testing. A wall chart illustrating warm-up exercises will be posted at each station.

ii) Second, following this warm-up the subjects then will familiarize himself/herself with the task by performing designed practice protocol(s). Each subject wil be given as much practice as desired and the helpful hints explained earlier (on task performance, safety, etc.) will be reinforced during this practice as well; the practice session will require only mild-to-moderate physical exertion on the part of the subject.

iii) Following practice and short respite, when the subject feels ready, that test will begin.

iv) Finally, f llowing performance, warm-down procedures will be conducted by a Tester, until the subject feels fully recovered; it is expected this should take (approximately) 10 minutes.

Subject Discomfort, Risk and Safety Procedure

Subject safety will be a foremost consideration. Although it is conceivable that subjects may experience a strained muscle during performance of these tasks, the warm-up routine that will be provided makes this highly unlikely. However, if a subject feels any task is too demanding, the task may be terminated at any time without coercion; this will be stressed to subjects before any testing is undertaken.

As well, for such healthy subjects 35 years and older the American College of Sports Medicine (A.C.S.M.) recommends that the upper limit of work intensity that should be sustained over any period of time is equivalent to 90% of the subject's heart rate reserve (A.C.S.M., Guidelines for Graded Exercise Testing and Exercise Prescription (3rd Edition) Phila: Lea & Febiger, 1986. pp. 36-40). Therefore, subjects in this age category (≥35 years) will wear a heart rate monitor which will be present to give an audible sound (buzzer) when the heart rate exceed 90% of this age-adjusted maximal value. If this monitor indicates heart rates in excess of that value that test shall be stopped immediately with no opportunity for that subject to continue. This safety precaution also will be fully explained to subjects before any testing is undertaken.

As well, a number of necessary and prudent precautions will be taken to reduce subject risk and ensure safety:

i) Queen's will provide a telephone at the site in case of emergencies. All personnel administering the tests will have undergone CPR instruction and emergency training drills prior to testing.

ii) All testing equipment has been constructed/inspected by licenced Engineers; This policy is implemented to ensure the structure and safety of all equipments to be used.

iii) By test Station, a number of safety procedures and precautions will be implemented according to that Station; for example, in addition to instructions, warm-up and practice:

- at all lifting Stations, wide leather weight-belts will be worn by subjects to provide waist and lower back support;
- at all carrying Stations, weight-belt and gloves will be worn for support and protection;
- at the Low High Crawl Station, securely fastened knee and elbow guards will be worn, with gloves and helmet also worn for protection of these body parts;
- and so on.

iv) As well, a number of more minor areas of concerns will be attended to; for example,

- kits will be available containing necessary first-aid items (such as bactin ointment, band-aids and bandages, sun screen ointment, etc.);
- a readily available supply of water;
- emergency phone numbers, means of communication, and emergency procedure will be carefully detailed;
- special seminars and instructions by qualified CPR personnel regarding subject safety and comfort will be given to all Laboratory Personnel <u>prior to</u> the study.

ADDENDUM

Because of the authoritative structure inherent in the Canadian Armed Forces, considerable resistance exists to having their CF Personnel whom the CF will both provide for this study and certify as to their medical and physical preparedness for participation in the study-sign any Informed Consent Form. In actuality, a delicate balance exists: on the one hand, the Forces' authority structure to command their Personnel versus, on the other, the ethical obligations of the Ergonomics Research Laboratory and Queen's University towards our subjects. Based upon our previous work with the CF, the undersigned faculty members of Queen's University feel very confident in our protocols and procedures (detailed in the foregoing); indeed, as we trust is very plainly evident to the CF, to the subjects themselves, and to ethics Reviewers, at length and in detail we have implemented all ethical and prudent measures to ensure subject safety and eliminate risk. And we would emphasize, short of their Personnel signing any Informal consent, the CF concurs and strongly supports these various measures outlined in the foregoing; in paricular, they are in agreement:

- that their Personnel be given every opportunity to discontinue any test at any point;
- that the test personnel at every Station be given full licence to explain and express these vital options and concerns to subjects prior to testing.

Therefore, incorporated into every phase of procedure at each test Station in effect is provided the opportunity for the subject to decide not to participate (in that particular test)/ to discontinue (that test) at any point/or to complete that test, however he/she so chooses; the implications of this statement will be emphasized to subjects repeatedly leading up to actually testing, as well as a statement to this effect read aloud prior to any physical participation by subjects (see section: Informing Subjects and Subjects Participation, iv), b)).

Date: ______________________ ______________________

Dr. J.M. Stevenson
(Principal Investigator)

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Dr. J.T. Bryant

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Dr. G.M. Andrew

APPENDIX C

DETAILED TASK METHODOLOGIES

A15

Ergonomics Research Laboratory
Queen's University at Kingston
School of Physical and Health Education
Department of Mechanical Engineering

MPFS PHASE III: Validation of Fitness Standards for Women and Older Men in the Canadian Armed Forces

Protocol Manual

May 21, 1987

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ERGONOMICS RESEARCH LABORATORY
QUEEN'S UNIVERSITY at KINGSTON
SCHOOL of PHYSICAL and HEALTH EDUCATION
DEPARTMENT of MECHANICAL ENGINEERING

MINIMUM PHYSICAL FITNESS STANDARDS STUDY: PHASE III

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards for all military personnel. The underlying principal is that there are certain duties which all personnel, even those in otherwise sedentary jobs, must be able to perform if called upon in an emergency. Common military tasks have been identified by the CF as being critical. Queen's University has been contracted to investigate the specific fitness requirements of the most difficult tasks.

In 1985 and 1986, The Ergonomics Research Laboratory at Queen's University was contracted by the CF to investigate the specific fitness requirements of these tasks. The testing over the summers of '85 and '86 allowed us to present to the military a preliminary profile of the fitness demands of the tasks and, thus, to suggest minimum fitness requirements for men and women. Queen's has once again been contracted by the military to continue the investigation of the fitness requirements of these stated military tasks and to verify and/or modify the standards initially proposed; specifically:

1) to validate the minimum physical fitness standard of younger women and older men;

2) to identify and to quantify those components of physical fitness involved in the performance of these tasks by older women.

The Ergonomics Research Laboratory has been contracted to conduct this study at Queen's University commencing June 1, 1987. Our laboratory personnel will carry out the test procedures which are outlined below. One morning or one afternoon will be allotted for completion of each test, with 20 to 25 CF personnel being tested at each station.

Low High Crawl Station

Each person will crawl over grass-like terrain, first crawling low (i.e., with all body parts close to the ground) for 30 m under low barriers, then crawling high (i.e., on hands and knees) for 45 m while carrying a model rifle. Total time will be recorded.

Entrenchment Dig Station

Each person will dig a one-person entrenchment 1.8 m long x 0.6 m wide to a depth of 0.45 m. The entrenchment will be simulated by a wooden box of this size filled with moistened, finely crushed rock. The total time taken to complete the dig will be recorded.

Casualty Evacuation Stations

Land Evacuation

Participants will evacuate a stretcher, carrying a load of 80 kg (simulating a wounded person), over flat terrain for a distance of .75 km. The other end of the stretcher will be fixed onto a wheel base, thus making this a one-person task; the total time will be scored.

Shipboard Evacuation

Up and down a flight of stairs (i.e., simulating shipboard stairs) one person in fire-fighting gear will evacuate a stoker stretcher which has one end fixed onto a sliding track. Before ascending the stairs, the stretcher will be moved 25 m over land to the base of the stairs. After descending the stairs the stretcher will be returned 25 m to the starting point. The total time taken to complete the evacuation will be recorded.

Sandbag Carry Station

Over a ten minute test period participants will carry sandbags (weighing 20 kg) one at a time a distance of 50 m, setting each bag down then returning for the next bag. The number of sandbags carried will be scored.

Additional Tests

In addition to assessing the physiological and biomechanical demands of the above tasks, CF personnel wil be asked to perform the following test batteries which may be used to predict field test performance.

EXPRES Test

Canadian Forces EXPRES test, which includes measures of height, weight and resting blood pressure, Step-Test, Maximum Grip Strength Test, Sit-Ups and Push-Ups tests will be conducted by CF personnel prior to or immediately after the Ergonomics Research Laboratory testing.

Queen's Station

Queen's University tests which include Grip Strength Endurance, Flexed Arm Hang, Kin/Com and lifting tests using the Forces' own testing device, the Incremental Lifting Machine (ILM) will be conducted during the testing week.

Subject Participation and Safety

For the information of participants, at each station and prior to any testing, the procedures outlined below will be followed.

1. A detailed verbal description of the task will be given. As well, each subject will be directed to read the explanation of the task for that station in their handout.

2. A task demonstration will follow the explanation. Performed by the Station Testers, this will both explain and visually show the complete task protocol, the means of scoring and highlight necessary skills.

3. Throughout the explanation and demonstration, CF personnel will be encouraged to ask questions about their personal concerns. Following the demonstration, a formal question-and-answer period will be conducted so that all subjects are well informed of both the task and test expectations.

4. Warm-up and practice opportunity, where appropriate, will be given. On an individual basis, each subject will be conducted through the warm-up procedures for that station by a tester. In general, these warm-up procedures will be commenced within 10 to 15 minutes of testing. Following this warm-up procedure, the tester will familiarize the participants with the task. At the stations where appropriate, each participant will be given a practice session (requiring only mild to moderate physical exertion). The helpful hints (i.e., on task performance and safety) explained earlier will be reiterated.

Following practice and a short rest, when the subject feels ready, the test will begin. During these tasks, heart rate and other cardiovascular, muscle strength and/or endurance measures will be monitored by means of standard laboratory techniques.

General Safety Procedures

For healthy people 35 years of age and older, the upper limit of work intensity that will be allowed is 90% of that individual's heart rate reserve (see Table 1). Therefore participants in this age category, (i.e., $\geq$ 35 years) will wear a heart rate monitor which will give an audible signal when the heart rate exceeds the age-adjusted maximal value. If the monitor indicates a heart rate in excess of this value, the test will be stopped immediately. This is an important safety precaution taken for the participant's protection. As well, if anyone feels any task is too demanding, the test may be terminated at any time.

Following task performance, cool-down procedures will be conducted by a tester until the subject feels fully recovered, to a heart rate of < 120 beats per minute. It is expected that this should take approximately 10 minutes.

A number of safety procedures and precautions will be implemented according to standards developed for each station. For example, in addition to instruction, warm-up and practice: at all lifting stations wide leather weight belts will be worn by subjects to provide waist and lower back support; at all carrying stations, gloves (or other suitable protection for the hands) will be provided; and at the Low High Crawl station, securely fastened knee and elbow pads, gloves and a helmet will be worn for protection of these body parts. More minor safety concerns will also be adressed. For example, kits containing necessary first-aid items (i.e., bactin ointment, band-aids and bandages) and drinking water will be readily available. The safety procedure outlined below will be implemented in the event of illness or injury. A telephone located at the test site will provide a direct link to the emergency services operator.

Procedures

You have been selected by CF to participate in this study. The criteria used in these selection procedures include level of fitness, experience, age and sex to ensure a representative sample of the CF personnel.

On the first day of testing, the scientific background to the study will be outlined in a briefing session. At that time, all procedural details will be explained. Our research group requests that you arrive wearing civilian attire and carry any necessary clothing.

We appreciate your contribution to this project and welcome your questions and comments.

Safety Considerations

See attached sheet.

PARTICIPANT SAFETY

In our study of Minimal Physical Fitness Standards (MPFS), the Queen's Ergonomics Research Laboratory has placed importance on safety and the reduction of personal risk to our subjects. As such, we have formalized a number of general procedures which place a premium on safety throughout every phase of testing.

Pre-Test Phase

In the pre-test phase, our main concern is the psychological and physiological preparation of the participants for the task to follow. Each test, then, is preceded by a verbal description of the task, a task demonstration, and a question-and-answer period. Finally, when subjects are fully briefed, actual physical participation will begin with a warm-up.

The verbal description of the task will be given by the station testers according to a standardized format included in each task protocol. This description will be given to the subjects as a group, and then to each participant individually just prior to his/her testing. The repetition of a standardized task description will be helpful in both re-emphasizing safe task procedures and techniques required by a given task.

The task demonstration by station personnel provides participants with a further visual model of the task and its performance. Each tester will know the acceptable performance techniques for their station as well as those methods which are unacceptable. Both the correct and incorrect methods will be demonstrated so that all are well aware of them as well as the safety features relating to task performance. Demonstration of safety procedures is particularly important at the lifting stations (i.e., Truck Loading, Casualty Evacuation, Sandbag Carry, and the ILM station) where proper lifting technique is essential for safe task completion (see Lifting Guidelines, following).

Questions will be encouraged during both the verbal description and the task demonstration. However, a formal question-and-answer period will be conducted by station personnel, completing the instruction portion of the pre-test sequence. This question-and-answer period, like a number of our testing procedures, emphasizes the role of the participant in protecting their own safety. It is felt that with safety equipment, standardized procedures reducing the risk of accident, and information about testing and safety, the participants will be able to play an important role in ensuring their own safety. The question-and-answer period allows each participant to identify personal concerns so that the tester may address each concern individually, in preparation for correct and prudent procedures while testing.

Finally, participants will be instructed to warm-up and practice to prepare themselves for the task at hand. The task protocols contain instructions for proper warm-up to assure that the participant is gradually readied for exercise and, specifically, for the physical demands of the individual test station. Each participant will begin (approx.) 10-15 minutes prior to their test. The warm-ups require only mild to moderate exertion and prepare the particular muscle groups employed at each test station. An opportunity for practice is given following the warm-up at various test stations. For example, whereas the Low-High Crawl requires skills not immediately familiar to the participants, the Entrenchment Dig requires only that the participant be able to shovel gravel. Therefore, practice is part of the Low-High Crawl protocol, but is not included (ncr is it necessary) for the Entrenchment Dig.

Finally, in the pre-test phase, EVERY PARTICIPANT MUST BE INFORMED OF HIS/HER OPTION TO PARTICIPATE OR NOT TO PARTICIPATE. Each task protocol contains the following statement to the participants, "If you feel this task is too demanding, it may be terminated at any time." This means that before the test begins, or once it has begun, the participant may choose to stop the activity. Here again, we have found it necessary to depend upon the informed judgement of each participant regarding their own capacity to perform any particular task. Because we are not in a laboratory setting on the CF Bases, which would allow more comprehensive monitoring of the participants' responses to each task, each participant <u>must</u> have the option to terminate any activity when he/she wishes, or feels it necessary.

<u>Test Phase</u>

After ensuring task readiness in the pre-test phase, the test phase begins. Each participant will be equipped with the necessary safety gear to reduce the risk of injury during task performance. For example, lifting stations will be supplied with weight belts for back and waist support, as well as gloves, tape and chalk to protect the hands. The Box Lifting Station will have metal toe covers for the shoes to prevent any falling box from injuring the toes. Other protective equipment like helmets, and knee, elbow, and shin pads will be available at stations where protection for these body parts is required. We also require that participants $\geq$ 35 years wear a heart rate monitor. This monitor will give an audible sound when the heart rate exceeds 90 percent of that participant's heart rate reserve (see Table 1, in the Introduction, for this age-adjusted maximal value). When the monitor indicates heart rates in excess of that value, the test <u>will be stopped immediately</u> and the participant will commence his/her cool-down until fully recovered. The heart rate monitor is an important piece of safety equipment to ensure the safe testing of participants $\geq$ 35 years.

Throughout actual task performance, station personnel will watch the participant closely to assure that he/she is complying with all of the safety stipulations for the task. If unsafe methods are observed, the tester will advise the participant to modify his/her technique or change to an acceptable technique.

Post Test Phase

Upon completion or termination of a test, the participant must not be permitted to stop suddenly. Just as it took time to warm-up the body for exercise, a period for cooling down is also required in the post-test phase. Station personnel will ensure that the participant continues to move (usually, walking) until he/she feels fully recovered. Objective criteria which may be applied to evaluate full recovery is cessation of heavy breathing (heaving of the chest), commencement of quiet breathing, cessation of profuse sweating (if present at the termination point), and return of the heart rate to $\leq$ 120 bpm.. For some participants, and depending upon the severity of the exercise, cool-down may require up to 5-10 minutes.

There will be a supply of water at each test station for participants after the completion of their task.

LIFTING GUIDELINES

Many factors such as age, sex, and load characteristics (i.e., load mass, shape, etc.) are important determinants of a safe lift. Taking such factors into consideration, it has been determined that all but the lifts at the Stretcher Carry Stations are safe according to NIOSH standards. The Stretcher Carry tasks have posed a problem to our safety concerns in that the 80 kg mass on the stretchers exceeds both the Action Limit and the Maximum Permissible Limit advised by NIOSH. The 80 kg is necessary, however, to simulate a wounded Forces Personnel being evacuated. Therefore, the load weight has been accepted, but two points warrant re-emphasis:

- The tester may terminate a test if a participant does not comply with the lifting guidelines (outlined below) or appears to be straining excessively under the load.

- If the participant feels that the task is too demanding, it may be terminated at any time.

All of these points will be covered during the lifting station demonstrations, and the following lifting guidelines must be explained:

i) Keep the back as straight as possible at all times, with the neck hyperextended.
ii) During the initial phase of any lift, use the legs to lift the mass in a smooth continuous motion never jerking upward using the back. Then use the (straight) back and upper body to complete the lift.
iii) Maintain a pelvic tilt while carrying or holding any load.
iv) Avoid twisting the torso during any lift (i.e., lifts must be made with the load directly in front of the body).
v) Arching the back forward to begin the lift, or hyperextending (arching backwards) to complete a lift, are

unacceptable lifting techniques.

vi) Avoid bracing a load against the torso to aid lifting.

vii) The station tester will immediately advise any participant to modify their technique or to change to an acceptable technique when lifting is performed in a manner deemed unsafe.

First-Aid and Emergency Procedures

In the instance of injury, there will be a first-aid kit on hand supplied with the necessities for caring for minor cuts or injuries. Major injuries will be cared for by a physician, supplied by each CF Base. If the physician is not on the testing site, there will be pre-planned procedures for the emergency transport of patients. Refer to the following page for procedure documentation.

Safety of Testing Apparatus

The apparatus at all test stations has been approved by a licenced engineer. Prior to testing at the CF Bases, and each subsequent day of testing, all apparatus will be inspected to ensure that it is sturdy and operational.

Emergency Procedures

In the event of an emergency or other extenuating circumstances, the following procedure will be followed:

1. The task leader at the emergency site will assume the role of safety officer. This MPFS employee will designate duties such that:

   a. The second testor will remain with the injured person(s). This individual will start first aid immediately (i.e. A.R., C.P.R., control bleeding, minor injuries) and may call upon a designated participant for assistance.

   b. The third testor will assume crowd control and initiate evacuation procedures (if required).

   c. The Med A or an MPFS participant will be recruited as a fourth member of the evacuation team. It is the reponsibility of this individual to meet the ambulance, fire department, etc. at the appropriate entrance. He/she will accompany the injured person to the hospital and ensure that the necessary medical information is available. Once at the hospital, this individual will report, by telephone, to the School of Physical and Health Education and to the Military, the patient's status.

2. The task leader will use the emergency phone, located in the the arena, to call for help. This phone provides direct contact with the Queen's Emergency Report Centre. The operator will require the following information:

   Your name and activity
   Information about the injured person: type of injury, age, gender, nature of the accident
   The location of the accident
   Information as to where and who will meet the ambulance

3. At this point of the evacuation procedure, the safety officer will inform the main office of the school of Physical and Health Education of the situation and relay the information outlined in step 2.

4. Once the site has been evacuated and/or the injured person has been transported, the safety officer will take the necessary actions so that testing may resume/be postponed.

P.E.C. Emergency routes and pick-up locations

FROM	ROUTE/LOCATION
The Ground Floor (Men's Locker)	Through the squash court gallery to the north end and out onto Clergy Street.
The Ground Floor (Women's Locker)	Out onto the pool deck to the north door (beside Pool Spervisor's Office), down the north corrider and out onto Clergy Street
Arena	Out the north end doors onto Clergy Street

These routes are designated as emergency routes and the lower Clergy Street doors designated as an emergency exit.

Contact Phone Numbers

AGENCY	TELEPHONE
School of Physical and Health Education	
Main Office	545-2666
Dr. Joan Stevenson	545-4687
Ergonomics Research Lab	545-2658
Military Liaison Officer	545-2658
NOHQ-DPERA Capt. Morrison	1-995-8916

Notes:

1. The fourth member of the evacuation team will be identified during the Monday briefing session.

2. Medical information will be provided by the military via the military liason.

PARTICIPANT SCHEDULE

Queen's University, June 1 to August 14, 1987

Monday	13:00	Briefing
	13:30 to 16:30	Queen's Station
Tuesday	8:30 to 12:00	Entrenchment Dig (A)
		Low High Crawl (B)
	12:00 to 13:00	Lunch
	13:00 to 16:30	Entrenchment Dig (B)
		Low High Crawl (A)
Wednesday	8:30 to 12:00	Sea Stretcher Evacuation
	12:00 to 13:00	Lunch
	13:00 to 16:30	Sand Bag Carry
Thursday	8:30 to 12:00	Land Stretcher Evacuation
	12:00 to 13:00	Lunch
	13:00 to 16:30	Subject Repeats

REVISED SCHEDULE

August 3 to August 7

Tuesday	8:30	Briefing
	9:00 to 12:00	Queen's Station
	12:00 to 13:00	Lunch
	13:00 to 16:30	Entrenchment Dig (A)
		Low High Crawl (B)
Wednesday	8:30 to 12:00	Entrenchment Dig (B)
		Low High Crawl (A)
	12:00 to 13:00	Lunch
	1:00 to 16:30	Sea Stretcher Evacuation
Thursday	8:30 to 12:00	Sand Bag Carry
	12:00 to 13:00	Lunch
	1:00 to 16:30	Land Stretcher Evacuation / Subject Repeats

Queen's Station

Incremental Lifting Machine
Free-Style Protocol

Introduction

This task requires the performance of a free-style lift on an Incremental Lifting Machine (ILM). Weight is increased incrementally after each lift to determine an individual's maximum weight lifting capacity on lift from 24 cm to full extension.

Equipment Required

- ILM
- Displacement/Velocity (D/V) gauge
- 4 colored magnets (with lines)
- personal computer with Analog to Digital (A-D) converter and A-D control box
- stop watch, tape measure
- weight belts

Field Set-Up

The magnets are located beside the tape measure on the sides of the ILM to illustrate the target lift height. The two safety pins (one for the armature and one for the jack) are placed in a box beside the ILM. The D/V gauge is placed to the left of the jackall (behind the ILM) such that the cord, when attached to the metal screw at the back of the armature, is at a 90 degree angle to the floor.

The displacement input of the D/V gauge will be connected to channel 1 of the control box. This channel is switched "on", while all other channels are left "off". The "qilm" program (located on the "c" disk) is used to collect data.

Protocol

Warm-Up and Cool Down

The test will be preceded by warm-up exercises which stretch the muscles of the neck, arms, lower back and hamstrings.

Overview of Test Procedure

Prior to testing, the participant's body mass will be determined. The predicted maximal ILM score is then calculated from body mass as follows:

women - 0.24 x weight(kg) + 11.20 = predicted ILM max score
men - 0.07 x weight(kg) + 43.48 = predicted ILM max score

The starting weight for the test session is that weight which is five weight increments below the predicted maximum. Increments of 5 and 2.5 kg are used for men and women respectively.

Subjects will perform a series of lifts to their full extension.

Each subject will perform three practice lifts in order to acquire proper lifting technique. Lifting instructions (as outlined later in this protocol) will be read to the subject prior to his first practice trial. The lift weights for the practice trials for men and women are given in the tables below:

WOMEN

Body Weight (kg)	Starting Weight (kg)	Practice Weights (kg)		
50.1-60.0	12.5	10.0	10.0	10.0
60.1-70.0	15.0	10.0	10.0	12.5
70.1-85.0	17.5	10.0	12.5	15.0

MEN

Body Weight (kg)	Starting Weight (kg)	Practice Weights (kg)		
50.0-65.0	30.0	15.0	20.0	25.0
65.1-100.0	35.0	20.0	25.0	30.0

Data Collection

Data will be collected on the computer using the "QILM" program. Each trial will be identified by the subject's identification number (i.e. s222) followed by the lift type and trial number (i.e. A04s222). Data will also be recorded manually (see sample data sheet).

Instructions to Subjects

1. The purpose of this test is to determine the maximum weight that you can lift to your full extension on the ILM.

2. You may assume a starting position which is comfortable to you.

3. The tester will say " begin lifting". You will lift the armature to your full extension. You may make any number of stops during the lift, however you may not return to a stop once you have resumed the lift. You have a total of 10 seconds to perform the lift.

4. There will be a minimum 30 second rest period between trials. You may rest for as long as 2 minutes if you wish.

5. You will have 3 practice trials.

6. You will start your test at a weight determined by your body weight, which will be incremented by 5 kg for men and 2.5 kg for women after each successful lift.

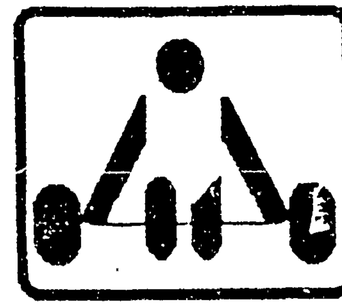
7. You should start warm-up exercises prior to your turn. Perform those exercises specified during the initial warm-up.

8. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on.)

9. If you feel this task is too demanding, it may be terminated at any time. The tester will stop you if it is felt you are violating safety restrictions.

10. Are there any questions?

MPFS 1987 - ILM RAW DATA SHEET



Name:_______________

Number:_______________

Body Weight: ______ kg

Starting Weight: _____ kg

Full Extension: ______ cm

Practice Trials

___ kg
___ kg
___ kg

Lift from 24 cm to full extension.

Trial	Identification	Directory c	Status p f	Weight kg
1	01c.prn		______	______
2	02c.		______	______
3	03c.		______	______
4	04c.		______	______
5	05c.		______	______
6	06c.		______	______
7	07c.		______	______
8	08c.		______	______
9	09c.		______	______
10	10c.		______	______
11	11c.		______	______
12	12c.		______	______
13	13c.		______	______
14	14c.		______	______
15	15c.		______	______

QUEEN'S STATION

Flexed Arm Hang

Introduction

This task is used to determine arm and upper body endurance. This task requires an all out effort to determine maximal score.

Equipment Required

- stop watch with sweep hand
- chin-up bar

Protocol

Warm-Up and Cool Down

The test is preceded by a stretching warm-up which includes exercises for the muscles of the neck, arms, and shoulders.

Overview of the Test Procedure

Adjust the bar to the subjects height. Have the subject grasp the bar with a reverse grip, hands shoulder width apart. When the subject becomes airborne with the body held such that the bar is at eye level, timing starts. Testers may steady legs if necessary. When the subject drops below eye level the test will end. The hang time is recorded to the nearest second.

Instructions to Subjects

The tester will read the following to the subject group:

1. This test requires that you hang at eye level from the bar as long as you can.

2. Once you are in position, at eye level, the time will begin. The tester may steady your legs if they sway.

3. Verbal encouragement will be given to help motivate you.

4. The test will end when you can no longer hold on at eye level.

5. If you feel this task is too demanding, it may be terminated at any time.

6. Are there any questions?

MPFS 1987 - FLEXED ARM HANG DATA SHEET

Name: ________________

Number: ________________

Total Time: ____________

Name: ________________

Number: ________________

Total Time: ____________

Name: ________________

Number: ________________

Total Time: ____________

Name: ________________

Number: ________________

Total Time: ____________

Name: ________________

Number: ________________

Total Time: ____________

Name: ________________

Number: ________________

Total Time: ____________

QUEEN'S STATION

20 kg Hand Grip Endurance Test

Introduction

The hand grip endurance test is designed to determine the length of time an individual can maintain a grip squeeze of 20 kg.

Equipment Required

- Personal computer with Analog to Digital (A-D) converter and A-D control box
- Printer for computer
- Hand Grip Dynamometer
- Break-out box (containing a 9-volt battery)
- software program (fatiguet.com)

Set-up

The hand grip dynamometer is plugged into the break-out box which is connected to the A-D control box (channel 2). The dynamometer handle must be adjusted to fit the grip of each hand of each participant prior to testing.

Protocol

Overview of Test Procedure

The computer program is designed to prompt the tester (for information) and the participant to begin a trial. To start the program, type "fatiguet". The first part of the program is a calibration routine for the dynamometer. Because a 9-volt battery is being used as a power source, the dynamometer must be calibrated before each trial. Simply follow the directions listed on the video screen.

Having completed the calibration, begin the test by pressing any key. Input the subject information (i.e., name, number and hand being tested) as it is requested on the screen. Ask the questions listed under 'Instructions to Subjects 1.' of that test. The dominant hand is that which is used to perform the majority of the functions described. Record the hand being tested (right vs. left and dominant vs. nondominant).

At the start signal ('beep') the subject will squeeze the grip until the dial reads 20 kg. Begin timing by pressing the space bar. When the participant's grip hold falls below 17 kg, the test will be terminated. The time will be printed to the screen, and to the printer. Repeat the test, with the participant using the other hand.

Data Collection

As information is collected, the program sends it directly to the printer. Thus, for each subject, there will be a print-out including participant identification information and the hold time. Record the answers to the hand dominance questions beside the subject information on the print-out sheet.

Instructions to Subjects

The tester will read the following to the participant:

1. This test is a determination of hand grip endurance time using a hand grip dynamometer. You are asked to complete the test once for each hand.

2. At the sound of the beep, squeeze the grip until the dial reads 20 kg. Continue holding at 20 kg as long as you can.

3. When your grip falls below 17 kg, a tone will sound and the test is over. The entire procedure will then be repeated with your other hand.

4. Are there any questions?

KIN/COM

Introduction

The purpose of this task is to investigate the static and dynamic strength of the arm flexors and extensors on the ability to lift weights to a fixed height.

Equipment Required

- one Kinetic Communicator Exercise System

Test Location

The strength measurement task will take place in the Fitness Centre at Queen's University using the KIN/COM exercise device.

Protocol

Warm-up and Cool Down

The test is preceded by a stretching routine, using chart 1 as a guide. After completing the test a cool down stretching routine is carried out.

Overview of the Test

The test is administered on the KIN/COM strength testing machine with a starting joint angle of 160° and a return angle of 30° at a velocity of 100°/sec for dynamic conditions. The static force is measured at a joint angle of 95°. Care must be taken to ensure that for every task the subject assumes a position that aligns the elbow joints centre of rotation with the machine centre of rotation to limit extraneous body movement.

Each subject is given three practice trials with every task followed by maximal concentric and eccentric contractions or a maximal static contraction. Work, power and force data from the maximal contractions are recorded and printed on a computer.

Instructions to Subjects

The tester will read the following to the subject group:

1) This test requires that you elicit maximal contractions under three different conditions: dynamic concentric, dynamic eccentric and static.

2) A concentric contraction causes a muscle to shorten; an eccentric contraction is one in which a muscle is forcefully lengthened as it attempts to shorten, while a static contraction is one in which no change in muscle length occurs. (The tester will then demonstrate each type of contraction with the elbow flexors and extensors.)

3) The elbow flexors are the muscle in the front of your upper arm while the elbow extensors are in the back of it.

4) The KIN/COM testing device is a computerized machine used to assess muscle strength. It controls the range of motion that you move lever arm through (the instructor should point out the lever arm) and the speed that you must move it.

5) The KIN/COM requires that you move the lever arm during a concentric contraction, but it requires that you resist the arms movement during an eccentric contraction.

6) The KIN/COM forces you to do an eccentric contraction immediately after you perform a concentric contraction.

7) Under a static contraction situation the lever arm remains at one preset position.

8) You will be given three practice trials with every task before you are asked to perform maximal contractions.

9) Verbal encouragement will be given to help motivate you.

10) Each test trial will end when the KIN/COM lever arm stops and/or when the synthesized voice informs you that the exercise is complete.

11) Remember that these are maximal contractions that require strenuous effort. If you feel that his task is too demanding, it may be terminated at any time by removing force application from the lever arm.

12) Are there any questions?

ENTRENCHMENT DIG

Introduction

The purpose of this task is to dig an entrenchment, measuring 1.8 m x 0.6 m x 0.45 m, as quickly as possible.

Equipment Required

- -4 shovels
- -2 pairs of leather gloves
- -1 stopwatch
- -3 heart rate monitors (Exersentry)
- -a proximately 0.80 cubic metres of 3/8 chips of gravel
- -water, enough to keep the gravel damp to control dust
- -2 weight belts
- -2 wooden boxes of the dimensions 1.8 m x 0.6 m x 0.45 m
- -2 platforms with the approximate dimensions 1.2 m x 2.0 m and a "lip" approximately 0.6 m high
- -volleyball referee's stand (i.e., observation platform for Tester)
- -step stool (i.e., a small flight of stairs)
- -water bottle
- -chalk (for the hands)
- -2 clipboards, pencils and data sheets

Dig Set-Up

Two boxes are placed side by side along their lengths, one being filled with crushed rock and leveled-off. A system of support planks, approximately 0.3 m wide, forms a ledge between the two boxes. A platform is attached with hinges to each box opposite the connecting ledge. Two more planks, at least 0.6 m in height, are placed along either side of the width of the box and connecting plank in order to completely enclose the two boxes and prevent crushed rock from scattering. A step stool is postioned such that the subject may use it to step up and into the dig apparatus. A volleyball referee's stand is situated close to the dig apparatus so that the testers can observe from above.

Protocol

Warm-up and Cool Down

The test is preceded by a run around the arena track. The task leader will then direct a warm-up according to charts 1 and 2. A designated tester will ensure that each participant warms up individually (i.e., stretches) immediately prior to their test session. After completing the test a cool down stretching routine is carried out.

Data Collection

Two Testers are necessary for this task. One, designated as the timer, is responsible for starting the test with the "go" command and indicating 15 s intervals. The second tester, the recorder, counts and records the number of digs performed by the participant during each 15 s interval. Counting is re-started every 15 s interval, but the stopwatch is not stopped so that there will be a total time showing when the subject has finished the task. The recorder should also note when the digging rhythm is interrupted, for example to change position, by writing an "x" beside the appropriate dig count. When the box has been emptied, the recorder gives the command "stop". Total time to complete the dig is recorded.

Instructions to Subjects

The tester should read the following instructions to the group of subjects:

1. This task is a simulation of a one-person foxhole dig.
2. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on).
3. Gloves will be provided, but you do not have to use them.
4. (Demonstrate shovel hold {2 types} and digging technique.)
5. You will start digging on the command "go".
6. You will clear the box, as fast a possible, pitching the crushed rock into the other box.
7. The test will end when you are given the command "stop".
8. If you feel that you have reached the end point before being told to stop, you should use the shovel in a "sweeping" action to gather the gravel into piles and continue clearing the box.
9. You should start warm-up exercises prior to your turn. Perform those exercises secified during the initial warm-up.
10. For those individuals 35 years or older heart-rate monitors will be worn for safety reasons. When the alarm sounds the instructor will tell you to stop performing the task. When the monitor stops beeping you will be instructed to continue.
11. If you feel this task is too demanding, it may be terminated at any time.
12. Are there any questions?

MPFS 1987- ENTRENCHMENT DIG DATA SHEET

Name: ______________

Number: ______________

Initial rate	(1/4 box)	______	shovelful/15 s
Middle rate	(1/2 box)	______	shovelful/15 s
End rate	(3/4 box)	______	shovelful/15 s

TOTAL TIME ______

NUMBER OF STOPS ______
(Heart rate monitor)

Name: ______________

Number: ______________

Initial rate	(1/4 box)	______	shovelful/15 s
Middle rate	(1/2 box)	______	shovelful/15 s
End rate	(3/4 box)	______	shovelful/15 s

TOTAL TIME ______

NUMBER OF STOPS ______
(Heart rate monitor)

Name: ______________

Number: ______________

Initial rate	(1/4 box)	______	shovelful/15 s
Middle rate	(1/2 box)	______	shovelful/15 s
End rate	(3/4 box)	______	shovelful/15 s

TOTAL TIME ______

NUMBER OF STOPS ______
(Heart rate monitor)

LOW HIGH CRAWL

Introduction

This task requires that the subject does a low crawl (i.e., with body parts close to the ground) for 30 m, turns and does a high crawl (on hands and knees) for 45 m in the fastest possible time.

Equipment Required

- 2 wooden models of rifle with sling
- 6 pylons
- stopwatch
- tape measure (50 m)
- 3 heart rate monitors
- 2 army helmets
- 8 volleyball knee pads
- 2 pairs of leather gloves
- 8 tensor bandages
- 30 metal stakes (106 cm) with holes at 60 cm
- 30 "C"-shaped bolts
- 30 nuts
- 15 wooden bars of the approximate dimensions 240cm x 5cm x 5cm
- 2 clipboards, pencils, data sheets

Field Set-Up

Refer to diagram below. Fifteen (15) barriers, each one made from a wooden bar, 2 "C"-shaped bolts, 2 nuts, and 2 metal stakes are placed 2 m apart for a distance of 28 m, in a straight line, to form the low-crawl "chute". Pylon #1 is placed at one end of the chute. Pylon #2 is placed 20 m from pylon #1. Fifteen metres from pylon #1 and 35 m from pylon#2, pylon #3 is placed. Two metres straight across from pylon #3, pylon #4 is placed. Twenty-five metres from pylon #4, pylon #5 is placed. Pylon #6 is placed 20m from pylon #5. Pylon #1 marks the start of the "test" course. Together pylons #6 and #7 mark the end of the chute with the subject turning 180 degrees around pylon # 7; pylons #3 and #4 mark the finish of the "test" course. Pylons #2 and #5 mark the start and finish, respectively, of the "pratice" course. Bean bags are placed along the course as shown by the diagram, such that together the pylons and bean bags mark 10 m intervals along the course.

Protocol

Warm-up and Cool Down

The test is preceded by a run around the arena track. The task leader will then direct a warm-up according to chart 1. A designated tester will ensure that each participant warms up individually (i.e., stretches) immediately prior to their test session. After completing the test a cool down stretching routine is carried out.

Overview of Test Procedure

Because this task is technically difficult, instruction on technique and a practice run will precede the actual test. The tester will be responsible for teaching and demonstrating the techniques as outlined below. Since the practice course is implemented to ensure use of the most efficient technique. the tester should make corrections or suggestions to subjects during this phase of testing. However, during the actual test, no further suggestions or encouragement may be provided. The subject will be given a sufficient rest period between the "practice" and "test". During this time the subject should warm up.

Data Collection

The tester will have a stopwatch with a memory and will record time for every 30 m as the subject moves through the course. This will be done for both the "practice" and "test" courses. The tester will record the final time for both the "practice" and "test" courses.

Instructions to Subjects

The tester will read the following to the subjects:

1. This task is a simulation of Forces Personnel in combat pinned down by enemy fire, moving accordingly, employing the low crawl and high crawl techniques. You will do the low crawl for 30 m and the high crawl for 45 m in the fastest possible time.

2. i) The low crawl is crawling on the elbows and the inside of the knees.
   ii) It is useful behind very low cover.
   iii) Propel yourself along with elbows and knees, rolling the body a little as each knee is bent. The heels, head, body, and elbows are kept down. The "chute" is a means of ensuring that the body is kept low.
   iv) Hold your weapon with one hand on the pistol grip or small of the butt and the other hand at the forestock with the cocking handle down. (At this point the tester demonstrates low crawl technique.)

3. i) The high crawl is simply crawling on hands and knees.
   ii) It is useful behind cover about sixty centimetres high.
   iii) The backside and head are kept down but observe as you move.
   iv) Hold the weapon in one hand during the crawl. You may change hands, but the weapon is not to be slung

over the back.
(At this point the tester demonstrates high crawl technique.)

4. Because the crawls are technically difficult, you will attempt a "practice" course before doing the "test" course.

5. If you feel this would be too demanding, it may be terminated at any time.

6. Are there any questions?

The "Practice" Course

The tester should walk through the "practice" course, noting starting points etc. as the following is read:

7. Start at pylon #2 lying flat on the stomach holding the rifle and wearing a helmet, gloves, elbow and knee pads.

8. On the command "go" you will begin a low crawl toward the end of the low crawl chute 10 m away.

9. At 10 m quickly get to your hands and knees, turn around pylon #7 and start a high crawl, along the high crawl course back to pylon #5 20 m away.

10. This warm-up course is for practice and technique; you will be given sufficient time to rest before beginning the "test".

N.B. During the "practice" course the tester may reiterate points of technique if the subject does not execute the crawls according to the aforementioned stipulations.

The "Test" Course

The tester should walk through the "test" course, noting starting points etc. as he/she reads the following:

11. Lie flat on your stomach at pylon #1 ready to start the "test" course.

12. On the command "go", begin a low crawl toward the end of the low crawl chute, 30 m away.

13. At 30 m quickly get to your hands and knees, turn and start a high crawl, along the high crawl course, to the finish marked by pylons #3 and #4.

14. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on.)

15. You should start warm-up exercises prior to your turn. Perform those exercises specified during the initial warm-up.

16. For those individuals 35 years or older heart-rate

monitors will be worn for safety reasons. When the alarm sounds the instructor will tell you to stop performing the task. When the monitor stops beeping you will be instructed to continue.

17. Are there any questions?

MPFS 1987 - LOW HIGH DATA SHEET

Name: ______________
Number: ____________

10-20m Course

0-10m

10-30m

Total (s)

30-45m Course

0-20m

20-30m

30-50m

50-75m

Total (s)

Name: ______________
Number: ____________

10-20m Course

0-10m

10-30m

Total (s)

30-45m Course

0-20m

20-30m

30-50m

50-75m

Total (s)

SHIPBOARD EVACUATION

Introduction

This task is a simulation of a casualty evacuation during a fire on board a ship. The subject is required to carry an 80 kg Stoker stretcher 25 m to the base of a flight of stairs, climb up the stairs to the deck above, then back down and return 25 m to the starting point. The time criterion is 10 minutes for completion of this task, an ample quantity of time; therefore, safety, not speed, should be the primary concern for the subject performing the task.

Equipment Required

- Stoker stretcher loaded with the equivalent weight of an 80 kg person (i.e., simulated by sandbags and weights firmly affixed).
- 25 m tape measure
- 1 pylon
- 4 cement blocks
- apparatus simulating stairs between deck levels (see description of "Shipboard Set-Up" below)
- sets of firefighting gear (i.e., coat, pants, boots, gloves, suspenders).
- one 15 kg free weight plate
- one 10 kg free weight plate
- data collection sheets
- clipboard, pens
- stopwatch with memory
- strong nylon rope
- soft mats
- heart rate monitors (Sport Testers)

Simulated Shipboard Set-Up

A simulation of a flight of stairs between two decks on a ship has been designed such that the task, moving a Stoker stretcher with Personnel weighing 80 kg up one deck, then back down, can be performed by one person - the subject.

A flight of iron stairs is securely attached to scaffolding 3 m in height, and set to the scaffolding at an angle of 60 degrees. Bolted to, and running along both sides of the stairs, are tracks. A moveable apparatus, whose wheels are in the tracks, spans the total width of the stairs, from one track across to the other. Attached to, and hanging freely below the crossbar of this moveable apparatus is the replication of the <u>rear half</u> of the Stoker stretcher. By means of a "pole and pin" device mounted into the bottom of this (simulated) stretcher, are free weights securely affixed. The total weight of the movable apparatus plus weight plates (25 kg) is 80 kg which the subject carries to the upper deck. A pulley system and nylon rope

serves as a safety device with pulleys attached to the crossbar above the (simulated) stretcher, and to the top of the tracks. The nylon rope, fed through this pulley system is controlled, from the ground, by one of the station personnel.

Twenty-five metres from the foot of the stairs, a pylon is placed. Alongside the base of the stairs, four cement blocks are placed 30 cm apart.

Protocol

Warm-Up

The task is preceded by a general cardiovascular and stretching warm-up (see charts 1 and 2) and followed by a cool down. After completing the test a cool down stretching routine is carried out.

Data Collection

Three testers are necessary for this task. One tester will control the safety rope during the test. A second tester will assist the subject by carrying the front end of the Stoker stretcher (with the subject at the rear) over the 25 m distance between the start pylon and the base of the stairs. The third tester will time the entire task according to the following schedule, and record:

i) from start to the end of the first 25 m carry when the Stoker stretcher is set down on the cement blocks at the base of the stairs.

ii) time of stair ascent: from the time the subject places the rear end of the stretcher on the cement blocks to the time the front wheels of the moveable apparatus hit the stopper at the top of the tracks.

iii) time of stair descent: including any rest pause the subject requires while at the top, from the time the moveable apparatus contacts the stoppers at the top until the back wheels hit the stoppers at the bottom.

iv) again, picking up the Stoker Stretcher off the cement blocks with the Tester assisting, the time is taken for the stretcher to be returned to the start.

Instructions to Subjects

The tester should read the following instructions to the group of subjects:

1. This task is a simulation of the evacuation of an injured person during a fire on board a ship; therefore, you are required to wear fire fighting gear.

2. While carrying the rear end of a Stoker stretcher, with 80 kg weight affixed and assisted in the carry by a tester at the front end, the stretcher is moved a distance of 25 m to the base of the stairs and set-down on the cement blocks.

3. After placing the stretcher down you will step to the bottom of the stairs, to the rear of the simulated Stoker stretcher and continue. (That is, this now becomes a one person task and the "stretcher" is moved up the stairs as if it were the one you just put down.)

4. The end point of the ascent occurs when the front wheels of the movable apparatus hit the stoppers at the top of the tracks. At this point you will be given a 5-second rest period automatically, but you may rest for longer if you so choose.

5. Signal with the command "O.K." when ready to descend.

6. You will move down the stairs, until the back wheels of the movable apparatus hit the stoppers at the bottom.

7. You will then step to the rear to the Stoker stretcher (resting on the cement blocks) and again carry it, (with the tester at the front end) back to the start pylon.

----

8. The following techniques are to be used when lifting and carrying the Stoker stretcher. It is not permitted to carry the rear end of the stretcher in any other way during the test.

Lifting and Carrying Techniques "On Deck":

When you are lifting the full-size stretcher with the assistance of a Tester, you should lift with your legs not your back (ie. keep your back straight, your neck hyper extended and bend your knees).
[The Tester demonstrates this lift.]

Stair Carrying Position:

To make the transition from the "deck" carry of the full-sized stretcher to the "stair" carry of the simulated rear-half of the stretcher, the simulator must be positioned onto the upper thighs (at the waist); this is defined as the 'stair climbing position'. This position is assumed using one of the following techniques:

i) The stretcher may be "muscled" up, using the arms only, and then placed onto the upper thighs; stronger individuals tend to use this technique.

ii) One knee may be used with the arms to more forcefully jerk the stretcher up onto the thighs.
[The Tester demonstrates these lifts.]

Stair Climbing Technique:

i) A "one-handed" technique may be used during the climb up and down the stairs: with the stretcher braced against your upper thighs (ie. by maintaining a bend at the waist) support the rear end with one hand. Grab the handrail with the other hand, and forcefully pull yourself up. Stronger individuals tend to use this technique employing a "normal" stair climbing gait. (i.e., one foot is placed on a step while the other moves to the next step above etc.).

OR ii) A "two-handed" technique may be used during the climb up and down the stairs: with the stretcher supported by, and braced against your upper thighs (i.e., by maintaining the bend at the waist), place the hands, one on each handrail, and use both arms to forcefully pull yourself up. Usually with this carrying technique the individual should employ "one-step-at-a-time" stair climbing.

[The tester demonstrates these lifts. At this point, each person in the subject group should be given the opportunity to try the "on-deck" lift, and to experiment with each of the two techniques outlined for the "Stair Carry Position" and "Stair Climbing

Technique", to determine which is most effective for him/herself. The subject should practice at first without the free weight plates secured in the stretcher. After establishing a technique, the subject should practice it with the full load. The practice climbs should include only 3 or 4 steps up and back down.

9. The following points of safety should be kept in mind while doing the test:

i) The handrails are shorter in length than the stairs. Be aware of where they stop, especially as you near the top and bottom of the stairs.

ii) Be aware of the projection replicating a hatch. Duck your head to avoid hitting it as you near the top of the stairs and as you descend from the top.

iii) Spotters and mats will be positioned at the base of the stairs, in the interest of safety. The testers will remind you of techniques and points of safety as you climb.

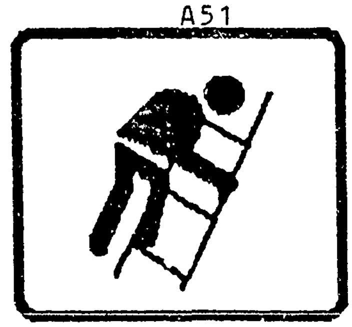
iv) The pulley system attached to the moveable apparatus will catch and support it immediately should the subject become exhausted (terminating the test) or slip.

10. The test will begin with the command "go" and timing will stop when the subject finishes the return 25 m distance.

11. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on.)

12. You should start warm-up exercises prior to your turn. Perform those exercises specified during the initial warm-up.

13. For those individuals 35 years or older heart-rate monitors will be worn for safety reasons. When the alarm sounds the instructor will tell you to stop performing the task. When the monitor stops beeping you will be instructed to continue.



MPFS 1987 - SHIPBOARD EVACUATION

NAME:

NUMBER:

times:

start - stairs: ______

up stairs: ______

down stairs: ______

stairs - finish: ______

final: ______

NAME:

NUMBER:

times:

start - stairs: ______

up stairs: ______

down stairs: ______

stairs - finish: ______

final: ______

SANDBAG CARRY

Introduction

The purpose of this task is to move one at a time as many 20 kg sandbags as possible a distance of 50 m over moderately rough terrain in 10 minutes.

Equipment Required

- sixteen 20 kg sandbags
- weigh scales
- 2 stop watches
- 25 m tape measure
- 6 pylons
- 3 weight belts
- wheelbarrel
- 2 clipboards, pencils, recording sheets
- 2 pairs of gloves
- water bottle
- heart rate monitors

Field Set-up

A straight 50 m run will be marked at 10 m intervals with pylons. Be sure it is clear of any objects (glass, rocks, etc.) which may cause harm to participants. Seven 20 kg sandbags will be placed at each end. In addition, an area with 2 sandbags for practice will be available.

Protocol

Warm-up and Cool Down

The test is preceded by a run around the arena track. The task leader will then direct a warm-up according to charts 1 and 2. A designated tester will ensure that each participant warms up individually (i.e., stretches) immediately prior to their test session. After completing the test a cool down stretching routine is carried out.

Overview of the Test

The tester is responsible for demonstrating the lifting and carrying techniques as described below. The acceptable techniques include carrying the sandbag: i) in your arms, close to your body (the baby carry); ii) as you would several logs, again, close to your body, (the log carry); iii) over your shoulder, with the weight distributed half in front, half behind (the shoulder carry); iv) over your shoulder, grasping one end with both hands and resting the weight down your back, (the santa carry); and v) a modification of the santa carry where one hand supports the bottom of the bag and the other holds the top (the modified santa carry).

During testing, a participant will wear a supportive weight belt and gloves are optional. The individual will practice the previously demonstrated lifting and carrying techniques to determine which style will be used during the task. Two people will be tested simultaneously starting at opposite ends of the 50 m track, each with a tester recording the number of bags moved. The subject may not pick up a bag until the time is started.

Data Collection

Each tester will have a stopwatch. The two testers will stand at opposite ends of the 50 m track. One designated tester will call "start" and both subjects will begin moving sandbags (in opposite directions). At 10 minutes both subjects will stop, and the distance from the start is recorded to the nearest 10 m.

The testers will record the time of each lift and drop, and record the total number of lifts (L to L = 1), plus .1 for each additional 10 m traveled up to 100 m.

Instructions to Subjects

The tester will read the following to the subject group:

1. This task is simulating an emergency flood control situation. You should imagine that you have a pile of sandbags in one location and must move them, as quickly as possible, 50 m away to the bank of a river. You may walk, run, or use any combination of walking and running while carrying bags or moving back to the starting position. You may only carry one sandbag at a time. Remember, the flood is happening 50 m away from your start location, so do not bring sandbags back!

2. When lifting the bags, you should use your legs, keep your back straight and maintain a pelvic tilt. Also, keep the weight as close to your body as possible. The following are the various acceptable techniques of lifting and carrying the bags: i) 'baby carry'; ii) 'log carry'; iii) shoulder carry; iv) neck carry; v) santa sac carry; and vi) modified santa carry. If you carry the bag in another fashion that seems to the testers to be dangerous you will be asked to change to one of the above techniques. [The tester will now demonstate the above techniques.]

3. It has been observed that subjects who maintain an even pace generally have their best performance.

4. You will be informed of the time remaining at (approximately) 2 minute intervals throughout the ten minute test.

5. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on.)

6. You should start warm-up exercises prior to your turn. Perform those exercises specified during the initial warm-up.

7. For those individuals ‑ ars or older heart-rate monitors will be worn for safet; ons. When the alarm sounds the instructor will tell you to s erforming the task. When the monitor stops beeping you will instructed to continue.

8. If you feel this task is too demanding, it may be terminated at any time.

9. Are there any questions?

MPFS 1987- Sandbag Carry

Name: ____________________

Number: ____________________

CYCLE	LIFT	(0-50 m)	DROP	(0-50 m)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				

LAND STRETCHER CARRY

Introduction

The purpose of this task is to carry a stretcher a distance of 75 m as quickly as possible. This is a simulation of the evacuation of an injured person.

Equipment Required

- 3 stretchers with modified wheel attachments
- adjustable weights (90 lbs -flat weights)
- 3 stop watches
- 5 signs labled 250m, 500m, 750m, and start
- gloves, chalk, tape, 2 weight belts, water bottle
- meter wheel (used to measure track)
- 2 clipboards, pens, recording sheets
- 3 heart rate monitors (Sport Testers)

Field Set-up

The land evacuation task will take place, ideally, around a 250 m track. If unavailable, pylons will be placed around any oval circuit at the beginning, 250 m, 500 m, 750 m and 1 km (i.e. end) points of the circuit.

Protocol

Warm-up and Cool Down

The test is preceded by a run around the arena track. The task leader will then direct a warm-up according to charts 1 and 6. A designated tester will ensure that each participant warms up individually (i.e., stretches) immediately prior to their test session. After completing the test a cool down stretching routine is carried out.

Overview of Test Procedure

The subject will start in front of the stretcher. At the start signal, participants will grip the stretcher handles, arms at the side and palms facing medially, then begin carrying the stretcher through the circuit.

Data Collection

The time and approximate distance (i.e., within 10 m) to the first drop will be recorded. Split times at 250 m, 500 m, 750 m and the time of each drop and lift throughout the task will also be recorded (see data collection sheet).

Instructions to Subjects

The tester will read the following to the subject group:

1. This task is simulating an emergency rescue situation. You are carrying a seriously injured person, 750 m to safety. You may walk, run, or any combination of walking and running. You may stop and rest at any time, however, the stretcher must be lowered to the ground and not dropped! The frequency and duration of the rest periods will be left to your discretion, but keep in mind that the purpose is to complete the task as quickly as possible. You may not use the stretcher apparatus as a rickshaw or wheelbarrel. Your arms, therefore, must remain relatively extended and straight.

2. You will wear a weight belt to give waist and back support. Gloves, chalk and tape are available to protect your hands.

3. As there are as many as 3 subjects on the course at one time, you may have to pass one another on the track.

4. You must wear a weight belt to give waist and back support. (Demonstrate how to put one on.)

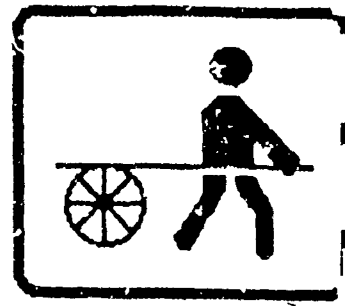
5. You should start warm-up exercises prior to your turn. Perform those exercises specified during the initial warm-up.

6. For those individuals 35 years or older heart-rate monitors will be worn for safety reasons. When the alarm sounds the instructor will tell you to stop performing the task. When the monitor stops beeping you will be instructed to continue.

7. If you feel this task is too demanding, it may be terminated at any time.

8. Are there any questions?

A58



MPFS 1987 - STRETCHER CARRY RAW DATA SHEET

Name:____________________

Number:__________________

Split Times

125 m __________

250 m __________

375 m __________

500 m __________

625 m __________

750 m __________

Name:____________________

Number:__________________

Split Times

125 m __________

250 m __________

375 m __________

500 m __________

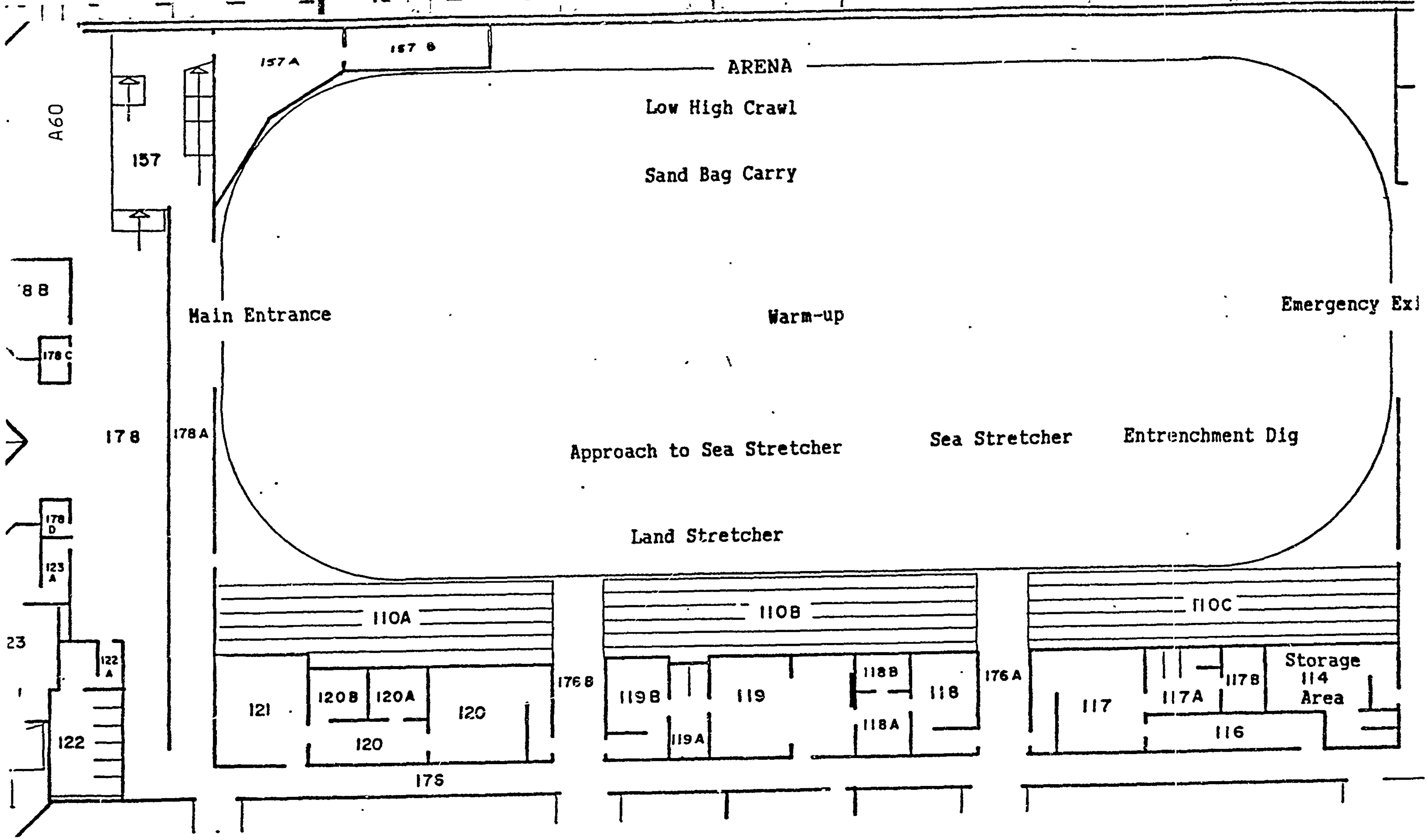
625 m __________

750 m __________

Table 1. Age-adjusted maximal heart rate for participants aged 35 years and older.

Age (years)	Maximum Allowable Heart Rate During Exercise * Women	Men
35	165	174
36	164	173
37	163	172
38	162	171
39	161	170
40	160	169
41	159	168
42	158	167
43	157	166
44	156	165
45	156	165
46	155	164
47	154	163
48	153	162
49	153	161
50	152	160

* If you are ≥ 35 years old, a buzzer will sound in your heart rate monitor if your heart rate exceeds the maximum allowable rate. When you hear the buzzer, stop the test and commence your warm-down; continue until you feel well recovered and back to normal.


A60
ARENA
Low High Crawl
Sand Bag Carry
Main Entrance
Warm-up
Emergency Exi
Approach to Sea Stretcher
Sea Stretcher
Entrenchment Dig
Land Stretcher
157
157 A
157 B
88
178 C
178
178 A
178 D
123 A
23
122 A
122
110A
110B
110C
121
120B
120A
120
120
176B
119B
119
119A
118B
118
118A
176A
117
117A
117B
Storage 114 Area
116
176

MPFS Participant Information
(CONFIDENTIAL)

Name: ____________________ SIN: ________________

D. HEALTH APPRAISAL QUESTIONNAIRE / ÉVALUATION DE LA SANTÉ

This questionnaire is a screening device to identify those members for whom physical activity might be inappropriate at the present time.

Ce questionnaire est un outil de travail dont le but est d'identifier les personnes pour qui, l'exercice physique est présentement contre indiquée.

To the best of your knowledge:	YES OUI	NO NON	Au meilleur de votre connaissance:
1. Do you have a restricted medical category which may prevent you from being evaluated or participating in a progressive training program?	☐	☐	1. Vous a-t-on attribué une catégorie médicale restreinte pouvant vous empêcher de subir une évaluation ou de participer à un programme de conditionnement physique progressif?
2. Do you have any recurring problems with your back, shoulders, hips, knees or ankles which may prevent you from being evaluated or participating in a progressive training program?	☐	☐	2. Souffrez-vous périodiquement de maux de dos, des épaules, des hanches, des genoux ou des chevilles pouvant vous empêcher de subir une évaluation ou de participer à un programme de conditionnement physique progressif?
3. Do you suffer from such things as: High blood pressure, heart disease, asthma, bronchitis, emphysema, diabetes, epilepsy, arthritis or cancer?	☐	☐	3. Souffrez-vous de l'un ou l'autre des troubles suivants: hypertension artérielle, maladie de coeur, asthme, bronchite, emphysème, diabète, épilepsie, arthrite, cancer?
4. In addition to the above is there anything which you feel should be discussed with a medical officer prior to assessment or training?	☐	☐	4. En plus de questions précédentes, y-a-t'il quelque chose qui devraient faire l'objet d'une discussion avec un médecin militaire avant une évaluation ou avant que entrepreniez le programme de conditionnement physique?
5. Are you taking medication (prescribed or otherwise) which may affect your ability to undertake a physical evaluation?	☐	☐	5. Prenez-vous des médicaments (prescrits ou non-prescrits) pouvant vous empêcher de subir l'évaluation d'aptitude physique?

OHIP Number: ________________

Next of Kin:
Name: ________________ Relationship: ______________
Address: ______________________________
____
Phone: ________________

Medical Considerations:
Allergy: ______________
Medication: ______________
____
Other: ______________

MPFS Identification Number: ____

ENCL 6
PIÈCE J

National Defence / Défense nationale

ASSESSMENT AND PRESCRIPTION REPORT - CF EXPRES

RAPPORT D'ÉVALUATION ET PRESCRIPTION - EXPRES FC

A62

I EVALUATION

A. NAME - NOM	INIT.	SIN - NAS	UNIT - UNITÉ	UIC - CIU	TEL. - TÉLÉ.

RANK - GRADE	CODE	TRADE - MÉTIER	MOC - CEM	DOB - DDN	AGE-ÂGE	SEX - SEXE

B. HEALTH APPRAISAL QUESTIONNAIRE/ÉVALUATION DE LA SANTÉ

This questionnaire is a screening device to identify those members for whom physical activity might be inappropriate at the present time.

"To the best of your knowledge is there any reason why you should not be evaluated or participate in a progressive physical training program?"

YES / OUI ☐ NO / NON ☐

Ce questionnaire est un outil de travail dont le but est d'identifier les personnes pour qui, l'exercice physique est présentement contre indiquée.

"Au meilleur de votre connaissance, est ce qu'il y a des raisons pour lesquelles vous ne pouvez pas subir une évaluation ou participer à un programme de conditionnement physique progressif?"

NOTE: SEE CF EXPRES WALL CHART OR BACK OF THIS FORM.
NOTA: VOIR L'AFFICHE MURALE DE L'EXPRES FC OU LE VERSO DE CE FORMULAIRE

C. RESTING PUSLE (bpm) / FRÉQUENCE CARDIAQUE AU REPOS (b/m)

RESTING BLOOD PRESSURE (mmHg) / TENSION ARTÉRIELLE AU REPOS (mmHg) — SYSTOLIC / SYSTOLIQUE — DIASTOLIC / DIASTOLIQUE

D.

WEIGHT (kg) / POIDS

HEIGHT (cm) / TAILLE

MAXIMUM WEIGHT (kg) / POIDS MAXIMAL

E. GIRTHS/CIRCONFÉRENCES (cm)

1. CHEST / POITRINE
2. WAIST / ABDOMEN
3. GLUTEAL / FESSIERS
4. RIGHT THIGH / CUISSE DROITE

MEN - DIFFERENCE / HOMME - DIFFÉRENCE (1 — 2)

WOMEN - SUM / FEMME - SOMME (1 + 2 + 3 + 4)

DESIRED DIFFERENCE/DESIRED SUM / DIFFÉRENCE DÉSIRÉE/SOMME DÉSIRÉE ________ CM

CM TO LOSE / CM À PERDRE ________ CM

WEIGHT TO LOSE / POIDS À PERDRE ________ KG

F. CARDIORESPIRATORY FITNESS - CAPACITÉ CARDIORESPIRATOIRE

HEART RATE RESPONSE - FRÉQUENCE CARDIAQUE À L'EFFORT

STAGE / ÉTAPE	STAGE / ÉTAPE	STAGE / ÉTAPE	STAGE / ÉTAPE
PULSE-POULS F.C. (10 sec)	PULSE-POULS F.C. (10 sec)	PULSE-POULS F.C. (10 sec)	PULSE-POULS F.C. (10 sec)
bpm	bpm	bpm	bpm

NOTE: BPM = PULSE (10 SEC) X 6
NOTA: bpm = POULS (10 SEC) X 6

LSC / DEC

FHR / FCF

PREDICTED VO_2 max - PRÉDITE (ml/kg/min)

FACTOR / FACTEUR 2 ____ .

FACTOR / FACTEUR 3 (+) ____ .

FACTOR / FACTEUR 8 (=) ____ .

FACTOR / FACTEUR A ____ .

FACTOR / FACTEUR B (−) ____ .

VO_2 max (=) ____ .

G. MUSCULAR STRENGTH / FORCE MUSCULAIRE (kg)

			MAX MUM
RIGHT HAND / MAIN DROITE	1	2	
LEFT HAND / MAIN GAUCHE	1	2	

TOTAL

H. MUSCULAR ENDURANCE MUSCULAIRE

1. PUSH-UPS / EXTENTIONS DES BRAS
2. SIT-UPS / REDRESSEMENTS ASSIS

SURG/CF PHYSICAL TRAINNING PROGRAM MEDICAL REFERRAL — MÉD C/DEMANDE D EXAMEN DE CONDITIONNEMENT PHYSIQUE DES FC

SIN-NAS	RANK-GRADE	NAME-NOM	INIT.	UNIT-UNITÉ
1.				

HAS BEEN SCREENED FOR PARTICIPATION IN PHYSICAL FITNESS ASSESSMENT AND TRAINING AND IS REFERRED FOR THE FOLLOWING REASON(S).

- ☐ A. NEGATIVE STATEMENT OF SUITABILITY
- ☐ B. BP OVER 140/90
- ☐ C. HEART RATE (RESTING) OVER 100
- ☐ D. BODY WEIGHT EXCEEDS LIMITS
- ☐ E. OTHER (SPECIFY)

A ÉTÉ EXAMINÉ AUX FINS DE L APPRÉCIATION D APTITUDE PHYSIQUE ET DE SA PARTICIPATION AU PROGRAMME DE CONDITIONNEMENT PHYSIQUE ET VOUS EST ADRESSÉ POUR LA(LES) RAISON(S) SUIVANTE(S)

- ☐ A DÉCLARATION D'INCAPACITÉ
- ☐ B. TENSION ARTÉRIELLE DE PLUS DE 140/90
- ☐ C. POULS AU REPOS DE PLUS DE 100
- ☐ D. POIDS EXCESSIF
- ☐ E. AUTRES (PRÉCISER)

ENCLOSURE: DND 279 ☐ BPERO (SIGNATURE)

APPENDIX D

RAW DATA OF SUB-STUDY ON EFFECTS OF HEART RATE RESTRICTION

Raw data for subjects who performed the entrenchment dig under restricted and unrestricted conditions.

Subject I.D.	Age In Years	*Maximal Oxygen Consumption ml/kg/min	Unrestricted Performance: True 100% Heart Rate beats/min	Unrestricted Performance: Entrenchment Dig (100%) seconds	Restricted Performance: Predicted 90% Heart Rate beats/min	Restricted Performance: Entrenchment Dig (90%) seconds
Males						
1409	35	47.4	200	306	174	566
1503	35	48.8	208	227	174	464
1602	36	45.8	189	286	173	445
1301	38	31.8	190	239	171	216
1604	38	45.0	209	360	171	646
1702	38	44.3	183	511	171	470
1804	38	44.6	186	362	171	316
1603	40	32.6	189	218	169	301
1703	40	39.5	165	369	169	300
1701	41	37.0	176	317	168	375
1302	44	36.2	173	318	165	260
1401	44	28.8	176	334	165	604
1403	45	36.6	189	266	165	501
1404	45	45.8	181	245	165	637
1803	49	37.2	175	269	161	273
1801	49	40.6	179	234	161	248
Females						
1709	39	33.3	197	448.9	170	490
1509	40	39.8	185	325.0	169	483
1305	40	36.3	184	487.7	169	680

* A maximal oxygen consumption test was used to determine true maximal heart rate.

APPENDIX E

1987 MPFS III RAW DATA

EXPRES DATA

ID#	AGE	SEX	HEIGHT (cm)	WEIGHT (kg)	VO2MAX	MAX GRIP (kg)	SITUPS (#)	PUSHUPS (#)
101	44	1	168	66	41.6	107	31	18
102	34	1	181	82	45.8	114	35	15
103	37	2	166	84	27.7	54	23	2
104	39	1	172	71	-1.0	100	62	62
105	28	2	162	61	39.6	70	18	8
106	36	2	163	59	39.2	62	31	6
108	36	2	165	67	34.9	48	21	6
109	23	2	158	60	50.2	67	18	8
201	47	1	171	69	39.4	111	30	30
202	35	2	169	61	35.0	60	14	5
203	38	2	161	54	31.5	53	36	5
204	40	1	175	68	47.8	115	49	40
205	51	1	178	68	31.3	108	30	22
206	39	2	151	60	32.6	47	19	15
208	38	2	171	55	35.3	66	27	7
209	37	2	163	52	35.0	66	35	10
301	36	1	178	87	44.4	113	40	30
303	39	2	172	64	33.3	80	40	21
304	40	1	184	85	37.8	141	20	30
305	52	1	174	100	35.6	102	20	25
306	38	2	165	75	29.2	72	32	13
307	26	2	167	58	32.6	56	31	8
309	36	2	166	68	34.0	46	24	1
401	39	1	176	93	42.7	118	19	18
402	44	1	170	72	39.3	125	28	20
403	27	2	167	61	40.6	71	43	46
404	41	1	170	83	37.6	125	17	20
405	41	1	176	81	33.8	116	19	21
408	38	2	152	55	35.3	37	26	35
409	37	2	174	58	35.0	55	28	14
501	44	1	174	69	35.6	131	39	30
502	22	2	166	58	35.9	59	48	20
503	53	1	176	84	34.8	106	25	17
504	28	2	168	[illegible]	35.3	53	28	10
505	48	1	177	78	37.9	87	44	25
506	22	2	161	59	31.0	66	18	8
508	25	2	177	82	34.4	67	26	10
509	37	2	171	63	31.7	59	28	13
601	42	1	176	85	38.8	130	25	25
602	44	2	166	68	35.2	69	42	30
603	41	1	168	77	38.7	101	42	25
605	46	1	176	83	35.8	143	27	20
607	37	2	163	74	38.1	66	23	0
608	30	2	166	72	32.8	65	18	8
609	41	2	156	70	27.5	50	14	7
701	45	1	181	92	44.6	114	34	12
702	25	2	173	64	42.2	83	59	25
703	52	1	176	84	37.0	96	23	15
704	23	2	164	57	43.8	79	36	19
705	24	2	159	56	37.5	81	19	20
706	41	1	176	88	41.7	159	30	25
707	41	1	168	79	43.9	100	26	30
708	26	2	172	91	30.8	78	26	12
709	30	2	168	62	41.0	80	52	29

ID#	AGE	SEX	HEIGHT (cm)	WEIGHT (kg)	VO2MAX	MAX GRIP (kg)	SITUPS (#)	PUSHUPS (#)
710	37	2	160	63	34.7	45	25	5
801	45	1	175	72	35.3	90	30	10
802	26	2	160	64	38.5	75	34	26
803	28	2	168	69	37.5	70	26	18
804	40	1	176	78	46.1	113	47	40
805	29	2	158	53	36.9	81	32	15
806	39	1	179	72	57.4	103	47	60
807	37	1	185	91	43.7	130	35	38
808	24	2	180	60	37.4	74	21	14
809	28	2	170	76	36.4	71	48	50
901	31	2	162	70	31.7	76	35	12
902	37	1	175	93	43.1	81	40	29
903	26	2	172	55	41.8	72	57	10
905	40	1	182	77	53.5	138	55	81
906	26	2	168	58	36.4	79	44	21
907	23	2	174	65	36.5	72	19	8
908	40	1	174	85	37.6	106	25	50
909	37	2	168	67	31.8	44	20	5
1001	25	2	162	53	38.3	89	46	30
1002	23	2	152	52	39.5	83	42	43
1003	31	2	174	76	34.8	89	16	0
1004	27	2	158	57	35.9	52	23	9
1005	23	2	171	77	36.2	66	30	15
1006	28	2	174	75	30.4	78	40	16
1007	27	2	170	71	39.2	72	35	12
1008	21	2	161	66	34.3	62	38	22
1009	39	2	165	78	32.4	48	22	1
1101	40	1	177	72	56.3	104	51	33
1102	47	1	177	83	37.0	100	26	20
1104	31	2	157	61	32.2	54	25	9
1105	18	2	172	62	38.2	78	32	15
1106	25	2	168	66	35.9	89	40	16
1107	45	1	165	75	36.1	110	27	32
1108	46	1	176	71	38.0	106	30	30
1109	39	2	170	67	35.4	67	16	5
1201	49	1	178	91	36.9	123	28	21
1202	36	1	164	69	43.2	66	38	30
1203	25	2	164	67	32.3	91	27	14
1204	27	2	163	80	34.1	68	36	10
1205	19	2	168	69	40.2	74	24	12
1206	18	2	159	59	40.1	69	32	15
1207	20	2	155	68	41.2	76	28	16
1208	29	2	160	70	35.1	81	32	10
1209	37	2	160	74	30.4	44	14	6
1303	39	1	175	67	44.6	93	36	25
1307	28	2		58	34.7	43	20	70
1308	20	2		71	33.5	74	43	20
1309	28	2	168	65	37.3	90	39	25
1402	45	1	170	93	37.1	130	30	23
1405	39	2		92	27.8	69	4	5
1406	21	2	167	66	39.3	78	7	17
1407	27	2	165	54	34.3	85	48	15
1408	25	2	166	65	37.9	98	34	20
1501	36	1	178	95	43.7	108	37	47

EXPRES DATA

ID#	AGE	SEX	HEIGHT (cm)	WEIGHT (kg)	VO2MAX	MAX GRIP (kg)	SITUPS (#)	PUSHUPS (#)
1502	49	1	188	96	31.5	101	25	10
1504	40	1	180	79	38.8	95	19	11
1505	42	2	165	74	31.8	56	28	5
1506	28	2	174	68	38.2	78	32	12
1507	27	2	174	73	31.4	81	29	18
1508	32	2	169	60	36.2	61	18	8
1601	48	1	166	78	37.3	103	22	17
1605	51	1	184	100	30.4	130	16	8
1607	24	2	164	61	40.8	85	51	20
1608	30	2		59	38.7	85	43	25
1609	30	2	158	49	37.5	56	32	31
1704	37	2	170	84	28.7	75	9	0
1705	43	1	164	72	35.3	126	24	25
1706	34	2	152	69	31.7	58	16	2
1707	24	2	161	51	39.3	71	30	30
1708	28	2	165	60	38.0	65	18	8
1802	46	1	188	85	43.0	129	31	20
1805	37	1	171	70	57.8	128	42	37
1806	24	2	153	49	35.7	58	30	10
1807	22	2	160	64	38.1	81	52	32
1809	36	1		76	38.1	122	23	26
1603	40	1	178	112	32.6	116	29	34
1503	35	1	172	66	48.8	103	31	31
1801	49	1		88	40.6	139	39	15
1301	38	1	165	74	31.8	56	28	5
1404	45	1	189	88	45.8	13.8	37	42
1403	45	1	172	87	36.6	102	8	24
1803	49	1	178	86	37.2	113	34	42
1304	45	1	177	78	44.1	127	42	22
1602	36	1	180	69	45.8	87	31	28
1409	35	1	177	63	47.4	102	37	44
1701	41	1	178	81	37.0	91	30	13
1302	44	1	178	89	36.2	125	32	16
1509	40	2	172	70	39.8	71	41	21
1401	44	1		73				
1604	38	1	166	67	45.0	109	37	18
1606	32	2	164	63	40.0	81	53	30
1804	38	1	174	78	44.6	99	32	20
1703	40	1	177	77	39.5	116	26	25
1709	39	2		65	33.3	75	25	5
1305	40	2	175	64	36.3	58	14	7
1702	38	1	176	80	44.3	107	25	18
1808	30	2	158	56	38.3	75	34	23

QUEEN'S STATION

ID#	AGE	SEX	ILM (kg)	ENDURANCE GRIP (s)	ENDURANCE GRIP (s)	TOTAL GRIP (s)	FLEXED ARM (s)
101	44	1	35.0	180	98	278	36.1
102	34	1	50.0	153	137	290	36.9
103	37	2	25.0	51	30	81	0.0
104	39	1	45.0	69	140	209	35.1
105	28	2	40.0	64	45	109	23.0
106	36	2	25.0	51	51	102	12.1
108	36	2	25.0	30	38	68	2.9
109	23	2	32.5	33	12	45	27.0
201	47	1	50.0	116	84	200	50.5
202	35	2	25.0	22	24	46	0.0
203	38	2	25.0	15	38	53	7.8
204	40	1	45.0	100	69	169	76.1
205	51	1	50.0	80	39	119	34.0
206	39	2	27.5	40	28	68	31.2
208	38	2	20.0	74	86	160	33.0
209	37	2	32.5	63	56	119	45.8
301	36	1	55.0	81	141	222	38.2
303	39	2	32.5	134	102	236	34.0
304	40	1	60.0	240	261	501	33.5
305	52	1	50.0	80	89	169	2.2
306	38	2	42.5	74	58	132	13.0
307	26	2	27.5	61	31	92	8.3
309	36	2	25.0	23	9	32	1.5
401	39	1	55.0	143	106	249	12.6
402	44	1	45.0	78	61	139	8.6
403	27	2	32.5	91	92	183	43.2
404	41	1	55.0	121	92	213	16.1
405	41	1	45.0	93	95	188	28.1
408	38	2	22.5	12	13	25	6.8
409	37	2	30.0	29	12	41	7.5
501	44	1	40.0	80	30	110	44.3
502	22	2	27.5	28	19	47	8.0
503	53	1	60.0	124	87	211	32.0
504	28	2	32.5	19	11	30	5.6
505	48	1	45.0	118	80	198	41.5
506	22	2	27.5	85	33	118	9.6
508	25	2	32.5	104	72	176	0.0
509	37	2	20.0	46	24	70	1.7
601	42	1	65.0	58	57	115	11.3
602	44	2	35.0	144	131	275	35.0
603	41	1	40.0	117	93	210	17.3
605	46	1	70.0	111	59	170	33.0
607	37	2	25.0	43	36	79	0.0
608	30	2	30.0	77	73	150	12.5
609	41	2	22.5	34	16	50	0.0
701	45	1	45.0	165	119	284	8.8
702	25	2	35.0	25	49	73	31.8
703	52	1	55.0	113	108	221	6.1
704	23	2	27.5	60	19	79	29.0
705	24	2	35.0	47	26	73	30.8
706	41	1	65.0	250	240	490	28.0
707	41	1	50.0	73	74	147	34.4
708	26	2	35.0	60	61	122	4.0

ID#	AGE	SEX	ILM (kg)	ENDURANCE GRIP (s)	ENDURANCE GRIP (s)	TOTAL GRIP (s)	FLEXED ARM (s)
709	30	2	27.5	24	27	51	34.7
710	37	2	25.0	22	17	39	3.0
801	45	1	40.0	165	67	231	28.4
802	26	2	35.0	61	27	88	4.0
803	28	2	25.0	16	8	25	12.9
804	40	1	60.0	138	134	272	31.2
805	29	2	35.0	98	66	164	45.6
806	39	1	65.0	196	87	282	67.0
807	37	1	70.0	206	238	444	42.6
808	24	2	27.5	16	19	36	35.5
809	28	2	55.0	110	92	203	42.2
901	31	2	35.0	48	41	89	5.0
902	37	1	55.0	95	45	140	11.0
903	26	2	27.5	24	34	58	22.2
905	40	1	80.0	240	307	547	50.0
906	26	2	25.0	28	19	47	22.4
907	23	2	25.0	23	21	44	5.2
908	40	1	55.0	128	113	241	14.0
909	37	2	22.5	33	7	40	2.0
1001	25	2	37.5	37	33	69	51.0
1002	23	2	30.0	30	25	55	51.0
1003	31	2	27.5	99	38	136	0.0
1004	27	2	25.0	22	26	48	5.9
1005	23	2	32.5	27	37	65	8.0
1006	28	2	35.0	66	39	105	10.0
1007	27	2	30.0	78	46	124	18.7
1008	21	2	30.0	9	27	36	12.4
1009	39	2	35.0	19	11	30	3.0
1101	40	1	65.0	107	61	169	66.3
1102	47	1	45.0	86	52	137	8.6
1104	31	2	20.0	22	5	27	1.2
1105	18	2	27.5	40	41	82	28.0
1106	25	2	30.0	95	51	146	13.1
1107	45	1	50.0	112	56	169	11.2
1108	46	1	40.0	71	80	151	26.0
1109	39	2	32.5	103	67	171	23.5
1201	49	1	50.0	170	161	331	31.0
1202	36	1	55.0	186	86	272	42.0
1203	25	2	25.0	12	4	15	0.0
1204	27	2	35.0	82	37	119	2.6
1205	19	2	32.5	64	73	137	16.5
1206	18	2	25.0	10	6	16	4.0
1207	20	2	30.0	47	24	71	3.5
1208	29	2	32.5	42	37	79	6.1
1209	37	2	25.0	40	11	51	0.0
1303	39	1	45.0	55	38	93	29.4
1307	28	2	30.0	29	33	61	43.5
1308	20	2	32.5	63	61	124	10.0
1309	28	2	27.5	63	23	86	11.0
1402	45	1	55.0	59	74	133	25.0
1405	39	2	27.5	60	31	92	0.0
1406	21	2	30.0	27	20	47	9.0
1407	27	2	30.0	27	39	67	48.6

ID#	AGE	SEX	ILM (kg)	ENDURANCE GRIP (s)	ENDURANCE GRIP (s)	TOTAL GRIP (s)	FLEXED ARM (s)
1408	25	2	37.5	94	63	157	19.0
1501	36	1	75.0	192	125	317	23.8
1502	49	1	50.0	24	35	59	11.1
1504	40	1	40.0	180	111	291	22.6
1505	42	2	30.0	57	32	89	8.6
1506	28	2	32.5	31	18	50	6.1
1507	27	2	32.5	32	58	90	10.5
1508	32	2	22.5	40	15	56	11.0
1601	48	1	55.0	54	25	78	22.1
1605	51	1	45.0	189	145	335	12.0
1607	24	2	32.5	49	52	102	26.1
1608	30	2	37.5	96	67	163	62.0
1609	30	2	30.0	27	15	41	30.8
1704	37	2	22.5	30	16	46	0.0
1705	43	1	50.0	119	60	178	31.3
1705	34	2	25.0	16	3	19	0.0
1707	24	2	30.0	27	35	62	60.0
1708	28	2	27.5	24	22	46	23.0
1802	46	1	60.0	128	107	235	37.1
1805	37	1	50.0	139	150	289	54.0
1806	24	2	22.5	14	3	18	10.5
1807	22	2	35.0	39	31	70	32.0
1809	36	1	45.0	107	169	276	37.0
1603	40	1	60.0	133	120	253	10.6
1503	35	1	40.0	84	56	139	45.8
1801	49	1	70.0	234	260	494	21.0
1301	38	1	50.0	85	41	126	48.5
1404	45	1	75.0	263	255	518	60.2
1403	45	1	55.0	170	123	293	36.1
1803	49	1	55.0	136	87	223	3.0
1304	45	1	50.0	151	131	282	19.6
1602	36	1	45.0	99	91	190	40.6
1409	35	1	50.0	135	88	223	61.5
1701	41	1	45.0	66	61	127	39.2
1302	44	1	60.0	107	96	202	28.0
1509	40	2	22.5	76	56	132	24.2
1401	44	1	45.0	111	87	198	32.7
1604	38	1	40.0	96	93	189	44.0
1606	32	2	37.5	67	32	99	57.8
1804	38	1	45.0	76	77	153	21.0
1703	40	1	50.0	182	120	302	22.0
1709	39	2	22.5	77	59	136	0.0
1305	40	2	20.0	27	24	52	19.5
1702	38	1	40.0	98	73	171	17.0
1808	30	2	25.0	42	30	72	12.0

LAND STRETCHER EVACUATION TASK (CUMULATIVE TIMES)

ID#	AGE	SEX	125 (s)	250 (s)	375 (s)	500 (s)	625 (s)	750 (s)
101	44	1	56.0	127.0	209.0	306.0	469.0	431.0
102	34	1	69.9	187.6	269.2	341.8	429.5	497.4
103	37	2	140.3	297.5	433.9	579.8	744.5	879.6
104	39	1	80.0	159.0	237.0	313.0	389.0	466.0
105	28	2	82.0	177.0	270.0	402.0	493.0	601.0
106	36	2	84.0	166.0	247.0	354.0	465.0	577.0
108	36	2	99.7	207.9	345.3	435.3	667.6	838.5
109	23	2	76.9	158.5	255.6	352.1	460.6	555.3
201	47	1	90.5	177.6	268.5	333.1	512.5	625.6
202	35	2	117.0	330.0	520.0	709.0	914.0	1103.0
203	38	2	206.1	457.5	693.0	827.3	1101.0	1329.1
204	40	1	67.9	134.1	200.5	277.5	350.5	401.4
205	51	1	99.0	241.0	473.0	606.0	778.0	1006.0
206	39	2	112.5	255.6	495.8	677.1	847.5	1019.6
208	38	2	99.0	225.0	407.0	559.0	688.0	880.0
209	37	2	116.0	239.0	330.0	438.0	545.0	631.0
301	36	1	67.0	136.0	206.0	275.0	349.0	406.0
303	39	2	80.0	196.0	304.0	422.0	561.0	683.0
304	40	1	71.0	139.0	207.0	274.0	344.0	414.0
305	52	1	86.0	169.0	246.0	336.0	428.0	523.0
306	38	2	132.0	208.0	438.0	600.0	784.0	954.0
307	26	2	106.0	240.0	381.0	535.0	693.0	856.0
309	36	2	219.0	477.0	829.0	1101.0	1329.0	1607.0
401	39	1	84.0	199.0	299.0	429.0	534.0	608.0
402	44	1	85.0	222.0	392.0	576.0	727.0	864.0
403	27	2	83.0	222.0	336.0	469.0	600.0	709.0
404	41	1	103.0	214.0	332.0	482.0	555.0	685.0
405	41	1	90.0	214.0	349.0	476.0	608.0	752.0
408	38	2	145.0	360.0	543.0	823.0	1060.0	1576.0
409	37	2	81.0	206.0	343.0	474.0	600.0	720.0
501	44	1	88.2	163.5	242.0	334.9	434.1	527.2
502	22	2	88.4	206.8	335.5	517.1	678.8	786.5
503	53	1	74.9	150.2	225.3	308.4	398.8	469.3
504	28	2	139.4	-1.0	-1.0	-1.0	-1.0	-1.0
505	48	1	85.2	172.2	255.8	351.4	451.6	546.8
506	22	2	132.8	306.5	466.2	636.5	732.4	897.6
508	25	2	88.9	178.1	297.5	355.4	467.9	694.7
509	37	2	194.0	356.0	518.0	631.0	826.0	1021.0
601	42	1	72.0	160.0	267.0	359.0	477.0	608.0
602	44	2	95.0	189.0	283.0	407.0	478.0	653.0
603	41	1	85.0	172.0	275.0	346.0	479.0	678.0
605	46	1	101.0	209.0	326.0	444.0	590.0	728.0
607	37	2	118.0	278.0	482.0	706.0	859.0	1014.0
608	30	2	129.0	243.0	427.0	579.0	760.0	1000.0
609	41	2	158.0	450.0	680.0	830.0	1015.0	1365.0
701	45	1	60.0	122.0	183.0	258.0	331.0	401.0
702	25	2	78.0	133.0	241.0	394.0	465.0	567.0
703	52	1	88.0	189.0	308.0	429.0	587.0	736.0
704	23	2	85.0	196.0	529.0	437.0	571.0	693.0
705	24	2	54.0	130.0	236.0	365.0	465.0	563.0
706	41	1	79.0	160.0	259.0	348.0	476.0	573.0
707	41	1	76.0	154.0	232.0	334.0	415.0	484.0
708	26	2	84.0	180.0	277.0	382.0	487.0	576.0

LAND STRETCHER EVACUATION TASK (CUMULATIVE TIMES)

ID#	AGE	SEX	125 (s)	250 (s)	375 (s)	500 (s)	625 (s)	750 (s)
709	30	2	68.0	142.0	222.0	311.0	411.0	507.0
710	37	2	110.0	238.0	415.0	639.0	913.0	1257.0
801	45	1	68.0	139.0	214.0	288.0	366.0	438.0
802	26	2	99.0	253.0	403.0	549.0	724.0	873.0
803	28	2	95.0	258.0	441.0	647.0	938.0	1009.0
804	40	1	86.0	166.0	243.0	325.0	397.0	469.0
805	29	2	88.0	211.0	334.0	481.0	664.0	809.0
806	39	1	57.0	115.0	173.0	233.0	293.0	375.0
807	37	1	46.0	134.0	145.0	178.0	252.0	297.0
808	24	2	77.0	177.0	263.0	384.0	503.0	608.0
809	28	2	66.0	133.0	208.0	288.0	369.0	445.0
901	31	2	63.0	188.0	353.0	550.0	849.0	1013.0
902	37	1	81.0	160.0	295.0	401.0	538.0	649.0
903	26	2	63.0	132.0	231.0	334.0	461.0	569.0
905	40	1	41.0	65.0	132.0	182.0	234.0	288.0
906	26	2	72.0	172.0	278.0	414.0	543.0	674.0
907	23	2	82.0	242.0	404.0	561.0	665.0	886.0
908	40	1	88.0	184.0	279.0	377.0	502.0	593.0
909	37	2	95.0	221.0	415.0	582.0	804.0	1069.0
1001	25	2	74.0	166.0	256.0	368.0	450.0	518.0
1002	23	2	85.0	215.0	348.0	445.0	548.0	672.0
1003	31	2	69.0	199.0	384.0	564.0	739.0	900.0
1004	27	2	69.0	186.0	336.0	481.0	656.0	801.0
1005	23	2	77.0	182.0	266.0	371.0	478.0	600.0
1006	28	2	88.0	197.0	317.0	418.0	536.0	654.0
1007	27	2	63.0	130.0	215.0	313.0	415.0	520.0
1008	21	2	79.0	192.0	292.0	415.0	560.0	698.0
1009	39	2	93.0	264.0	394.0	566.0	685.0	838.0
1101	40	1	41.0	85.0	142.0	200.0	254.0	296.0
1102	47	1	78.0	157.0	235.0	335.0	414.0	530.0
1104	31	2	139.0	402.0	662.0	1003.0	1380.0	1656.0
1105	18	2	58.0	167.0	336.0	475.0	658.0	773.0
1106	25	2	72.0	172.0	290.0	408.0	519.0	639.0
1107	45	1	76.0	210.0	326.0	457.0	602.0	770.0
1108	46	1	73.0	147.0	221.0	335.0	480.0	638.0
1109	39	2	81.0	163.0	245.0	371.0	496.0	615.0
1201	49	1	125.0	259.0	389.0	569.0	753.0	893.0
1202	36	1	79.0	170.0	256.0	346.0	449.0	549.0
1203	25	2	95.0	226.0	385.0	588.0	832.0	949.0
1204	27	2	90.0	195.0	351.0	524.0	690.0	844.0
1205	19	2	88.0	173.0	303.0	404.0	522.0	609.0
1206	18	2	86.0	189.0	313.0	433.0	581.0	748.0
1207	20	2	89.0	189.0	328.0	497.0	645.0	780.0
1208	29	2	99.0	229.0	372.0	504.0	650.0	808.0
1209	37	2	125.0	284.0	475.0	773.0	1017.0	1256.0
1303	39	1	94.0	185.0	276.0	411.0	528.0	653.0
1307	28	2	84.0	166.0	268.0	403.0	530.0	643.0
1308	20	2	55.0	212.0	248.0	363.0	494.0	618.0
1309	28	2	71.0	137.0	221.0	297.0	383.0	451.0
1402	45	1	76.0	183.0	318.0	474.0	646.0	827.0
1405	39	2	78.0	187.0	305.0	462.0	593.0	726.0
1406	21	2	108.0	133.0	431.0	567.0	760.0	929.0
1407	27	2	81.0	176.0	302.0	442.0	575.0	682.0

LAND STRETCHER EVACUATION TASK (CUMULATIVE TIMES)

ID#	AGE	SEX	125 (s)	250 (s)	375 (s)	500 (s)	625 (s)	750 (s)
1408	25	2	93.0	236.0	394.0	610.0	784.0	926.0
1501	36	1	68.3	141.5	212.4	300.3	391.7	478.1
1502	49	1	134.5	261.9	470.7	680.8	889.2	1084.0
1504	40	1	86.9	185.9	289.8	388.8	512.5	613.9
1505	42	2	95.8	263.7	435.9	585.7	797.1	964.0
1506	28	2	88.7	208.8	330.0	457.5	587.7	735.0
1507	27	2	73.6	180.1	300.8	455.0	613.4	780.7
1508	32	2	107.9	282.0	462.4	666.1	872.7	1092.6
1601	48	1	85.4	173.1	278.4	418.9	531.4	666.4
1605	51	1	81.1	168.9	256.3	355.8	485.7	608.8
1607	24	2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1608	30	2	69.8	165 3	254.4	364.1	472.0	568.5
1609	30	2	126.7	278.6	438.6	649.9	832.0	1007.0
1704	37	2	152.3	360.2	547.9	766.2	1051.2	1197.8
1705	43	1	86.9	221.8	357.4	534.9	718.1	894.2
1706	34	2	164.3	362.2	614.8	948.8	1203.4	1455.7
1707	24	2	85.1	188.6	321.8	473.1	627.6	771.6
1708	28	2	100.8	245.1	385.5	518.5	720.0	870.5
1802	46	1	62.0	135.0	244.0	352.0	436.0	504.0
1805	37	1	55.0	102.0	171.0	231.0	292.0	366.0
1806	24	2	95.0	222.0	404.0	594.0	840.0	1090.0
1807	22	2	68.0	150.0	234.0	350.0	468.0	554.0
1809	36	1						
1603	40	1	79.3	157.9	233.8	309.3	401.3	478.4
1503	35	1	75.1	163.7	254.4	353.6	450.9	559.7
1801	49	1	65.0	137.0	206.0	275.0	346.0	406.0
1301	38	1	70.0	140.0	223.0	309.0	411.0	489.0
1404	45	1	72.0	140.0	206.0	275.0	355.0	467.0
1403	45	1	82.0	190.0	320.0	436.0	568.0	683.0
1803	49	1	69.0	141.0	211.0	282.0	379.0	480.0
1304	45	1	70.0	142.0	241.0	377.0	426.0	540.0
1602	36	1	52.1	159.6	258.3	382.6	516.6	597.6
1409	35	1	84.0	170.0	299.0	399.0	502.0	598.0
1701	41	1	94.3	184.7	305.3	407.9	517.5	629.7
1302	44	1	60.0	126.0	203.0	266.0	339.0	441.0
1509	40	2	60.6	133.2	206.1	285.8	384.6	470.5
1401	44	1	87.0	191.0	317.0	436.0	595.0	700.0
1604	38	1	81.5	226.5	365.1	536.8	662.5	798.1
1606	32	2	77.2	203.1	359.3	-1.0	-1.0	-1.0
1804	38	1	80.0	156.0	239.0	340.0	430.0	534.0
1703	40	1	82.5	166.9	251.2	353.1	455.1	553.1
1709	39	2	85.0	180.3	282.6	411.3	569.2	678.6
1305	40	2	104.0	264.0	444.0	604.0	816.0	967.0
1702	38	1	104.2	216.8	330.5	474.1	627.9	771.5
1808	30	2	77.0	183.0	382.0	606.0	801.0	972.0

SANDBAG CARRY AND LOW-HIGH CRAWL TASKS

ID#	AGE	SEX	SANDBAG CYCLES (#)	0-20 (s)	20-30 TOTAL LOW (s)	30-50 (s)	TOTAL TIME (s)
101	44	1	9.7	40.2	61.2	87.6	113.4
102	34	1	14.4	27.4	39.7	59.9	80.3
103	37	2	8.0	120.7	213.4	268.5	314.4
104	39	1	15.3	28.1	40.7	58.2	76.9
105	28	2	13.5	58.1	81.6	98.5	120.4
106	36	2	12.0	55.4	105.6	134.5	159.6
108	36	2	10.3	57.1	91.0	129.3	157.8
109	23	2	14.4	31.9	55.9	79.6	102.0
201	47	1	11.9	30.7	48.2	66.3	89.7
202	35	2	10.5	52.7	96.4	144.9	174.0
203	38	2	7.5	87.6	135.4	195.0	227.7
204	40	1	15.8	29.9	44.3	63.0	80.8
205	51	1	8.2	50.8	74.2	114.1	140.4
206	39	2	7.8	37.2	59.9	90.3	122.8
208	38	2	10.0	38.7	64.8	98.1	126.1
209	37	2	9.0	25.2	40.0	60.9	86.1
301	36	1	13.0	30.2	44.3	106.2	150.8
303	39	2	11.2	47.8	86.9	116.6	144.5
304	40	1	12.7	50.9	68.7	109.2	144.6
305	52	1	11.1	121.3	187.6	285.7	330.7
306	38	2	9.0	63.6	112.7	169.4	216.9
307	26	2	12.2	74.6	117.3	158.9	189.8
309	36	2	9.5	114.7	180.3	236.2	289.6
401	39	1	12.5	51.8	82.4	125.8	171.0
402	44	1	10.3	53.9	92.7	155.1	201.1
403	27	2	11.4	42.7	67.8	95.8	119.4
404	41	1	10.5	93.6	154.7	208.8	254.6
405	41	1	10.0	140.9	201.3	267.2	320.4
408	38	2	9.0	105.5	179.4	247.2	302.9
409	37	2	9.0	103.8	147.8	207.7	258.0
501	44	1	9.7	33.0	55.1	78.4	100.5
502	22	2	12.1	38.6	59.1	88.6	114.0
503	53	1	12.3	37.7	84.4	111.4	137.7
504	28	2	11.0	62.7	109.5	141.2	169.9
505	48	1	10.8	41.6	58.7	88.8	117.7
506	22	2	9.9	45.2	75.9	107.0	132.7
508	25	2	9.9	70.4	117.6	159.2	196.4
509	37	2	8.5	74.9	139.9	188.9	227.5
601	42	1	10.3	34.6	55.3	153.3	179.4
602	44	2	10.0	87.5	134.7	169.2	194.8
603	41	1	10.2	35.5	48.7	75.9	99.4
605	46	1	9.5	28.0	45.2	64.1	86.2
607	37	2	11.0	57.0	105.0	140.7	172.3
608	30	2	10.2	40.0	79.4	114.4	146.5
609	41	2	8.0	115.4	200.0	249.4	325.7
701	45	1	11.9	29.5	48.0	67.8	88.0
702	25	2	13.4	36.9	66.6	92.5	116.9

SANDBAG CARRY AND LOW-HIGH CRAWL TASKS

ID#	AGE	SEX	SANDBAG CYCLES (#)	0-20 (s)	20-30 TOTAL LOW (s)	30-50 (s)	TOTAL TIME (s)
703	52	1	10.5	47.5	77.9	114.1	145.8
704	23	2	14.4	52.3	80.5	109.5	134.9
705	24	2	13.5	32.7	52.0	76.4	100.4
706	41	1	11.5	26.6	44.0	64.1	86.4
707	41	1	12.7	34.1	56.1	84.8	112.6
708	26	2	10.8	77.1	129.5	171.9	210.7
709	30	2	14.8	41.9	64.8	88.4	111.8
710	37	2	7.7	72.0	122.3	179.0	237.2
801	45	1	14.5	38.1	56.2	82.8	113.8
802	26	2	11.1	66.8	117.1	148.6	180.1
803	28	2	11.5	68.1	118.7	155.5	187.1
804	40	1	16.5	34.1	51.1	76.4	104.3
805	29	2	12.1	26.4	37.4	57.9	78.2
806	39	1	18.9	28.2	43.5	62.5	80.8
807	37	1	18.6	19.1	28.3	43.5	61.1
808	24	2	13.0	50.9	82.9	110.5	138.2
809	28	2	16.6	18.3	28.0	46.4	64.6
901	31	2	10.8	73.8	140.1	176.8	210.7
902	37	1	12.0	43.3	68.1	103.6	133.8
903	26	2	11.0	37.8	59.1	86.4	112.6
905	40	1		20.0	32.6	47.6	63.8
906	26	2	11.0	70.4	108.3	155.9	195.6
907	23	2	11.2	73.6	125.4	167.3	214.1
908	40	1	12.3	20.4	32.0	54.3	80.0
909	37	2	9.2	109.0	179.3	228.0	274.3
1001	25	2	15.4	33.3	50.0	79.8	108.0
1002	23	2	15.5	42.4	66.2	88.7	114.3
1003	31	2	12.0	88.2	137.5	169.3	199.4
1004	27	2	10.5	63.8	110.3	149.7	185.5
1005	23	2	15.2	38.2	63.2	93.6	118.6
1006	28	2	13.0	58.2	101.9	139.9	169.4
1007	27	2	17.6	53.6	85.0	111.3	136.0
1008	21	2	12.5	29.9	51.6	77.5	103.2
1009	39	2	10.2	78.6	128.0	182.9	227.5
1101	40	1	14.0	20.3	30.8	49.6	71.0
1102	47	1	9.0	31.6	50.4	75.9	105.7
1104	31	2	8.5	65.4	115.3	159.1	195.7
1105	18	2	13.0	63.0	108.2	139.8	168.3
1106	25	2	11.5	61.3	116.4	157.2	192.6
1107	45	1	8.5	37.8	73.0	116.5	152.0
1108	46	1	10.4	23.1	41.4	69.8	91.6
1109	39	2	12.0	57.5	109.4	142.5	175.8
1201	49	1	9.5	56.7	92.8	136.0	173.7
1202	36	1	10.1	33.5	53.3	76.9	101.4
1203	25	2	11.2	68.3	115.9	152.4	187.1
1204	27	2	11.0	65.1	93.4	125.6	152.8
1205	19	2	12.3	26.8	45.9	73.1	96.7

SANDBAG CARRY AND LOW-HIGH CRAWL TASKS

ID#	AGE	SEX	SANDBAG CYCLES (#)	0-20 (s)	20-30 TOTAL LOW (s)	30-50 (s)	TOTAL TIME (s)
1206	18	2	13.0	33.8	57.7	90.6	120.5
1207	20	2	10.5	32.9	60.3	92.6	126.2
1208	29	2	10.0	49.6	82.1	125.0	170.8
1209	37	2	9.2	64.6	104.0	154.8	208.6
1303	39	1	8.5	27.2	42.0	66.9	91.8
1307	28	2	13.0	42.7	75.4	105.2	129.1
1308	20	2	13.2	30.1	49.7	74.7	99.7
1309	28	2	14.2	27.7	44.1	64.8	86.5
1402	45	1	12.5	65.0	106.8	153.3	204.3
1405	39	2	10.5	107.5	174.3	214.5	250.5
1406	21	2	12.5	51.0	94.9	127.3	158.7
1407	27	2	14.0	57.4	88.4	118.9	149.5
1408	25	2	14.5	36.7	59.3	82.9	109.6
1501	36	1	14.5	21.7	32.1	51.2	76.2
1502	49	1	8.0	-1.0	-1.0	-1.0	-1.0
1504	40	1	9.5	98.8	149.5	206.8	241.6
1505	42	2	9.9	72.9	116.0	154.7	196.5
1506	28	2	10.3	54.9	86.9	121.7	151.7
1507	27	2	11.3	57.7	91.5	123.3	149.3
1508	32	2	8.3	56.6	109.2	144.3	193.8
1601	48	1	10.8	34.3	49.0	78.8	110.5
1605	51	1	11.2	45.3	81.7	133.7	176.9
1607	24	2	-1.0	33.9	55.2	79.5	102.8
1608	30	2	14.0	21.5	34.2	55.9	78.1
1609	30	2	11.5	38.9	69.6	101.3	134.0
1704	37	2	7.7	132.0	222.3	290.3	355.8
1705	43	1	9.7	43.3	65.5	102.9	141.6
1706	34	2	7.4	111.3	178.8	237.4	295.3
1707	24	2	10.5	36.9	56.1	83.1	105.2
1708	28	2	11.0	38.3	71.7	103.1	137.1
1802	46	1	14.5	35.8	54.1	79.1	99.4
1805	37	1	19.0	17.4	30.3	47.4	58.7
1806	24	2	10.0	42.9	75.5	110.9	147.4
1807	22	2	13.3	38.0	68.8	102.0	124.0
1809	36	1	12.0	16.5	26.6	43.4	62.8
1603	40	1	13.0	55.1	85.5	118.3	145.4
1503	35	1	12.6	18.8	28.1	45.1	62.8
1801	49	1	16.0	27.3	43.8	67.1	89.8
1301	38	1	12.0	25.7	41.5	63.2	86.7
1404	45	1	16.0	25.6	38.2	58.8	78.4
1403	45	1	10.9	36.0	55.4	81.1	104.8
1803	49	1	14.0	32.4	52.7	83.6	112.2
1304	45	1	11.5	35.3	55.0	79.7	109.6
1602	36	1	15.0	26.3	42.4	63.9	86.9
1409	35	1	12.4	17.2	26.9	45.0	65.2
1701	41	1	10.3	52.7	86.5	117.0	149.8
1302	44	1	13.3	35.7	60.6	87.1	111.1

SANDBAG CARRY AND LOW-HIGH CRAWL TASKS

ID#	AGE	SEX	SANDBAG CYCLES (#)	0-20 (s)	20-30 TOTAL LOW (s)	30-50 (s)	TOTAL TIME (s)
1509	40	2	12.0	71.0	114.0	148.7	176.4
1401	44	1	11.2	25.2	42.0	73.2	98.9
1604	38	1	10.5	28.8	45.5	69.6	95.0
1606	32	2	15.0	36.9	57.1	87.9	112.7
1804	38	1	14.2	38.0	57.1	86.2	111.9
1703	40	1	13.0	24.1	39.9	65.7	88.3
1709	39	2	10.0	54.3	89.8	121.8	146.5
1305	40	2	8.1	70.9	119.4	157.3	186.7
1702	38	1	11.5	56.8	87.2	120.4	152.0
1808	30	2	11.0	31.0	67.1	102.1	142.5

ENTRENCHMENT DIG AND SEA EVACUATION TASKS

ID#	AGE	SEX	ENTRENCHMENT DIG TIME (s)	STRETCHER-STAIRS (s)	UP STAIRS (s)	DOWN STAIRS (s)	TOTAL TIME (s)
101	44	1	408	5.1	19.3	27.6	34.0
102	34	1	256	4.5	14.6	20.8	26.1
103	37	2	719	6.6	155.7	185.1	198.0
104	39	1	285	7.0	22.1	32.8	41.0
105	28	2	362	4.8	17.8	27.3	33.0
106	36	2	448	5.3	32.7	57.9	64.6
108	36	2	482	9.6	83.6	105.3	114.3
109	23	2	463	6.0	68.3	82.6	93.1
201	47	1	809	3.6	13.5	19.0	23.7
202	35	2	541	-1.0	-1.0	-1.0	-1.0
203	38	2	1081	6.5	225.4	254.8	266.7
204	40	1	495	4.6	15.4	26.0	30.9
205	51	1	683	6.3	39.9	56.1	63.7
206	39	2	813	-1.0	-1.0	-1.0	-1.0
208	38	2	551	6.8	40.4	76.3	83.6
209	37	2	794	5.6	21.1	29.0	35.5
301	36	1	519	4.1	12.7	18.2	22.9
303	39	2	510	4.7	37.4	52.9	60.6
304	40	1	398	3.8	12.0	16.8	21.4
305	52	1	440	5.4	16.4	23.4	31.1
306	38	2	567	5.6	140.1	164.6	175.6
307	26	2	541	6.4	53.9	72.4	83.8
309	36	2	935	-1.0	-1.0	-1.0	-1.0
401	39	1	410	8.3	31.1	43.0	51.4
402	44	1	496	7.7	25.6	39.4	50.1
403	27	2	405	8.3	44.8	57.0	68.8
404	41	1	414	10.7	61.0	83.0	94.6
405	41	1	636	9.3	27.5	37.4	47.7
408	38	2	638	14.0	491.8	532.5	542.9
409	37	2	550	12.8	96.9	127.7	138.8
501	44	1	558	6.4	15.2	24.4	31.3
502	22	2	448	5.4	26.4	50.4	56.8
503	53	1	311	6.1	18.8	24.9	31.1
504	28	2	521	7.5	60.6	72.5	81.7
505	48	1	340	5.9	24.9	33.4	40.7
506	22	2	566	6.8	117.0	145.4	159.3
508	25	2	486	6.4	159.7	216.8	226.5
509	37	2	641	8.9	229.9	263.8	300.3
601	42	1	349	6.8	21.1	31.8	38.6
602	44	2	373	7.8	78.8	108.0	116.7
603	41	1	373	5.0	26.2	42.5	49.4
605	46	1	340	4.4	12.7	19.7	26.1
607	37	2	461	6.0	298.7	322.0	334.2
608	30	2	436	7.1	53.4	77.6	85.6
609	41	2	1038	14.7	698.5	732.4	775.3
701	45	1	232	4.5	14.4	23.2	29.1
702	25	2	523	5.0	16.3	26.7	33.1

ENTRENCHMENT DIG AND SEA EVACUATION TASKS

ID#	AGE	SEX	ENTRENCHMENT DIG TIME (s)	STRETCHER-STAIRS (s)	UP STAIRS (s)	DOWN STAIRS (s)	TOTAL TIME (s)
703	52	1	368	5.8	29.5	47.3	56.6
704	23	2	635	6.4	265.6	296.6	305.4
705	24	2	341	6.2	35.7	47.5	54.3
706	41	1	467	4.9	13.9	20.8	26.6
707	41	1	321	5.0	23.6	36.8	42.8
708	26	2	334	6.0	31.5	46.8	54.4
709	30	2	437	6.2	72.0	98.4	106.3
710	37	2	787	8.1	765.9	893.0	912.0
801	45	1	333	5.1	19.9	30.5	37.8
802	26	2	629	7.4	660.0	693.8	725.1
803	28	2	533	5.4	226.5	259.7	268.9
804	40	1	369	4.7	18.6	28.8	35.5
805	29	2	423	6.0	26.8	43.8	53.4
806	39	1	247	3.6	15.4	22.0	27.4
807	37	1	217	4.1	12.7	17.0	22.4
808	24	2	454	6.3	30.2	45.9	53.4
809	28	2	256	4.0	14.3	21.8	26.7
901	31	2	470	5.9	56.1	81.3	88.6
902	37	1	337	5.0	40.9	60.5	67.7
903	26	2	456	6.0	56.9	71.7	78.4
905	40	1	219				
906	26	2	679	6.0	57.4	88.4	99.4
907	23	2	505	5.5	186.0	207.4	218.9
908	40	1	316	4.3	17.0	25.8	31.8
909	37	2	707	-1.0	-1.0	-1.0	-1.0
1001	25	2	302	4.3	16.6	26.0	32.1
1002	23	2	365	5.1	75.5	95.1	103.7
1003	31	2	436	8.2	61.6	92.0	100.2
1004	27	2	821	6.5	196.2	226.9	242.3
1005	23	2	572	6.2	47.2	67.7	76.0
1006	28	2	475	5.1	267.0	301.3	312.7
1007	27	2	429	5.3	23.6	40.7	48.2
1008	21	2	380	5.6	74.8	94.1	100.3
1009	39	2	429	-1.0	-1.0	-1.0	-1.0
1101	40	1	258	3.7	11.7	17.2	22.2
1102	47	1	486	4.3	21.9	34.2	40.1
1104	31	2	700	-1.0	-1.0	-1.0	-1.0
1105	18	2	554	5.5	35.3	52.3	58.9
1106	25	2	456	5.2	45.0	69.9	76.2
1107	45	1	518	5.1	24.3	38.0	44.4
1108	46	1	512	4.9	34.1	47.6	53.7
1109	39	2	505	6.1	36.1	50.7	55.9
1201	49	1	569	5.1	25.2	39.1	46.1
1202	36	1	436	4.7	18.5	25.0	30.3
1203	25	2	575	7.0	154.1	195.3	205.2
1204	27	2	392	5.3	99.5	119.2	230.8
1205	19	2	418	5.6	22.5	34.5	42.1

ENTRENCHMENT DIG AND SEA EVACUATION TASKS

ID#	AGE	SEX	ENTRENCHMENT DIG TIME (s)	STRETCHER-STAIRS (s)	UP STAIRS (s)	DOWN STAIRS (s)	TOTAL TIME (s)
1206	18	2	540	4.7	331.4	365.0	381.8
1207	20	2	587	5.8	206.3	216.8	225.6
1208	29	2	761	6.6	699.9	733.0	746.5
1209	37	2	574	7.8	563.4	586.5	643.5
1303	39	1	358	5.4	23.7	40.8	48.9
1307	28	2	477	6.7	37.4	51.8	58.1
1308	20	2	449	5.4	37.3	50.1	56.4
1309	28	2	315	4.8	25.6	42.9	48.6
1402	45	1	380	5.3	33.2	53.8	61.5
1405	39	2	677	5.2	120.4	145.2	152.9
1406	21	2	500	5.7	90.5	116.3	125.6
1407	27	2	505	6.5	66.9	85.0	94.4
1408	25	2	379	4.5	19.3	27.1	32.9
1501	36	1	282	4.0	15.3	22.5	28.4
1502	49	1	696	6.1	66.1	86.9	96.6
1504	40	1	393	6.0	22.1	43.7	51.7
1505	42	2	691	8.3	312.0	325.3	333.6
1506	28	2	450	4.3	54.2	67.9	74.7
1507	27	2	526	5.2	29.0	56.0	63.6
1508	32	2	698	7.5	346.7	377.9	390.7
1601	48	1	511	5.0	28.7	40.4	49.7
1605	51	1	387	5.8	34.7	47.0	55.4
1607	24	2	508	5.4	35.9	59.3	66.7
1608	30	2	315	4.5	28.0	42.9	48.6
1609	30	2	645	6.9	103.0	127.0	139.0
1704	37	2	490	9.2	349.5	368.6	385.6
1705	43	1	562	3.8	23.7	31.0	37.1
1706	34	2	808	10.0	504.9	538.3	575.0
1707	24	2	483	6.8	49.5	62.4	71.4
1708	28	2	471	8.6	44.8	62.4	73.0
1802	46	1	336	5.2	31.9	43.4	50.2
1805	37	1	244	4.5	18.3	28.8	34.8
1806	24	2	953	-1.0	-1.0	-1.0	-1.0
1807	22	2	397	5.0	60.4	79.4	87.7
1809	36	1	259	4.4	15.3	24.4	30.5
1603	40	1	301	4.5	18.4	28.3	34.6
1503	35	1	464	3.8	13.2	20.8	25.6
1801	49	1	248	4.2	14.0	22.5	29.0
1301	38	1	216	4.8	13.9	20.0	24.5
1404	45	1	637	4.5	15.1	21.2	26.4
1403	45	1	501	3.9	27.3	35.8	42.1
1803	49	1	273	4.1	19.5	27.1	35.8
1304	45	1	260	4.3	17.9	24.9	31.4
1602	36	1	445	4.8	17.7	30.2	36.7
1409	35	1	566	5.3	23.4	35.7	42.3
1701	41	1	375	3.9	22.0	32.3	39.1
1302	44	1	260	3.4	16.5	26.3	32.4

ENTRENCHMENT DIG AND SEA EVACUATION TASKS

ID#	AGE	SEX	ENTRENCHMENT DIG TIME (s)	STRETCHER-STAIRS (s)	UP STAIRS (s)	DOWN STAIRS (s)	TOTAL TIME (s)
1509	40	2	483	5.5	50.6	100.9	108.6
1401	44	1	604	5.6	19.1	33.2	40.1
1604	38	1	646	4.2	17.0	25.6	33.1
1606	32	2	322	5.0	31.0	41.4	49.4
1804	38	1	316	4.7	34.3	46.9	53.7
1703	40	1	300	4.5	14.0	20.1	25.3
1709	39	2	490	5.5	38.4	63.9	72.1
1305	40	2	680	5.2	64.9	89.8	96.9
1702	38	1	470	4.9	23.9	36.7	46.9
1808	30	2	529	9.8	291.9	332.5	344.5

APPENDIX F

PARTICIPANT INFORMATION

A84

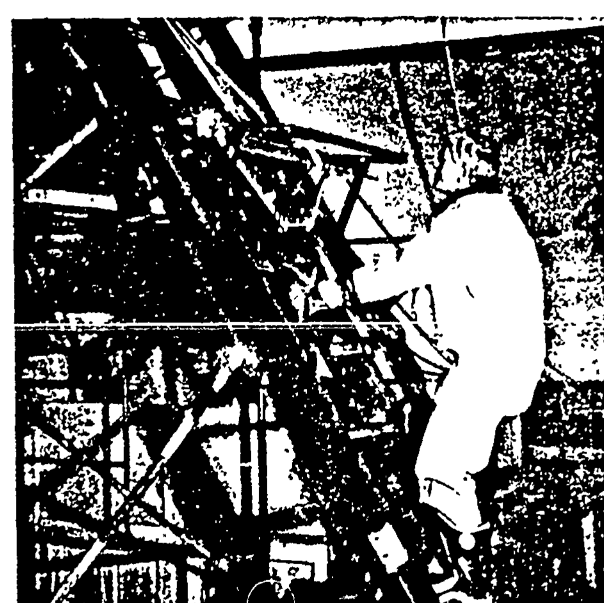
Ergonomics Research Laboratory
Queen's University at Kingston
School of Physical and Health Education
Department of Mechanical Engineering

Development of Minimum Physical Fitness Standards for the Canadian Armed Forces: Phase III

Participant Information

June 1, 1987 to August 14, 1987

Joan M. Stevenson, Ph.D.
George M. Andrew, Ph.D.
J. Timothy Bryant, Ph.D., P.Eng.
John M. Thomson, Ph.D.



ERGONOMICS RESEARCH LABORATORY
QUEEN'S UNIVERSITY at KINGSTON
SCHOOL of PHYSICAL and HEALTH EDUCATION
DEPARTMENT of MECHANICAL ENGINEERING

MINIMUM PHYSICAL FITNESS STANDARDS STUDY: PHASE III

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards for all military personnel. The underlying principal is that there are certain duties which all personnel, even those in otherwise sedentary jobs, must be able to perform if called upon in an emergency. Common military tasks have been identified by the CF as being critical. Queen's University has been contracted to investigate the specific fitness requirements of the most difficult tasks.

In 1985 and 1986, The Ergonomics Research Laboratory at Queen's University was contracted by the CF to investigate the specific fitness requirements of these tasks. The testing over the summers of '85 and '86 allowed us to present to the military a preliminary profile of the fitness demands of the tasks and, thus, to suggest minimum fitness requirements for men and women. Queen's has once again been contracted by the military to continue the investigation of the fitness requirements of these stated military tasks and to verify and/or modify the standards initially proposed; specifically:

1) to validate the minimum physical fitness standard of younger women and older men;

2) to identify and to quantify those components of physical fitness involved in the performance of these tasks by older women.

The Ergonomics Research Laboratory has been contracted to conduct this study at Queen's University commencing June 1, 1987. Our laboratory personnel will carry out the test procedures which are outlined below. One morning or one afternoon will be allotted for completion of each test, with 20 to 25 CF personnel being tested at each station.

Low High Crawl Station

Each person will crawl over grass-like terrain, first crawling low (i.e., with all body parts close to the ground) for 30 m under low barriers, then crawling high (i.e., on hands and knees) for 45 m while carrying a model rifle. Total time will be recorded.

Entrenchment Dig Station

Each person will dig a one-person entrenchment 1.8 m long x 0.6 m wide to a depth of 0.45 m. The entrenchment will be simulated by a wooden box of this size filled with moistened, finely crushed rock. The total time taken to complete the dig will be recorded.

Casualty Evacuation Stations

Land Evacuation

Participants will evacuate a stretcher, carrying a load of 80 kg (simulating a wounded person), over flat terrain for a distance of .75 km. The other end of the stretcher will be fixed onto a wheel base, thus making this a one-person task; the total time will be scored.

Shipboard Evacuation

Up and down a flight of stairs (i.e., simulating shipboard stairs) one person in fire-fighting gear will evacuate a stoker stretcher which has one end fixed onto a sliding track. Before ascending the stairs, the stretcher will be moved 25 m over land to the base of the stairs. After descending the stairs the stretcher will be returned 25 m to the starting point. The total time taken to complete the evacuation will be recorded.

Sandbag Carry Station

Over a ten minute test period participants will carry sandbags (weighing 20 kg) one at a time a distance of 50 m, setting each bag down then returning for the next bag. The number of sandbags carried will be scored.

Additional Tests

In addition to assessing the physiological and biomechanical demands of the above tasks, CF personnel wil be asked to perform the following test batteries which may be used to predict field test performance.

EXPRES Test

Canadian Forces EXPRES test, which includes measures of height, weight and resting blood pressure, Step-Test, Maximum Grip Strength Test, Sit-Ups and Push-Ups tests will be conducted by CF personnel prior to or immediately after the Ergonomics Research Laboratory testing.

Queen's Station

Queen's University tests which include Grip Strength Endurance, Flexed Arm Hang, Kin/Com and lifting tests using the Forces' own testing device, the Incremental Lifting Machine (ILM) will be conducted during the testing week.

Subject Participation and Safety

For the information of participants, at each station and prior to any testing, the procedures outlined below will be followed.

1. A detailed verbal description of the task will be given. As well, each subject will be directed to read the explanation of the task for that station in their handout.

2. A task demonstration will follow the explanation. Performed by the Station Testers, this will both explain and visually show the complete task protocol, the means of scoring and highlight necessary skills.

3. Throughout the explanation and demonstration, CF personnel will be encouraged to ask questions about their personal concerns. Following the demonstration, a formal question-and-answer period will be conducted so that all subjects are well informed of both the task and test expectations.

4. Warm-up and practice opportunity, where appropriate, will be given. On an individual basis, each subject will be conducted through the warm-up procedures for that station by a tester. In general, these warm-up procedures will be commenced within 10 to 15 minutes of testing. Following this warm-up procedure, the tester will familiarize the participants with the task. At the stations where appropriate, each participant will be given a practice session (requiring only mild to moderate physical exertion). The helpful hints (i.e., on task performance and safety) explained earlier will be reiterated.

Following practice and a short rest, when the subject feels ready, the test will begin. During these tasks, heart rate and other cardiovascular, muscle strength and/or endurance measures will be monitored by means of standard laboratory techniques.

General Safety Procedures

For healthy people 35 years of age and older, the upper limit of work intensity that will be allowed is 90% of that individual's heart rate reserve (see Table 1). Therefore participants in this age category, (i.e., $\geq$ 35 years) will wear a heart rate monitor which will give an audible signal when the heart rate exceeds the age-adjusted maximal value. If the monitor indicates a heart rate in excess of this value, the test will be stopped immediately. This is an important safety precaution taken for the participant's protection. As well, if anyone feels any task is too demanding, the test may be terminated at any time.

Following task performance, cool-down procedures will be conducted by a tester until the subject feels fully recovered, to a heart rate of < 120 beats per minute. It is expected that this should take approximately 10 minutes.

A number of safety procedures and precautions will be implemented according to standards developed for each station. For example, in addition to instruction, warm-up and practice: at all lifting stations wide leather weight belts will be worn by subjects to provide waist and lower back support; at all carrying stations, gloves (or other suitable protection for the hands) will be provided; and at the Low High Crawl station, securely fastened knee and elbow pads, gloves and a helmet will be worn for protection of these body parts. More minor safety concerns will also be adressed. For example, kits containing necessary first-aid items (i.e., bactin ointment, band-aids and bandages) and drinking water will be readily available. The safety procedure outlined below will be implemented in the event of illness or injury. A telephone located at the test site will provide a direct link to the emergency services operator.

Procedures

You have been selected by CF to participate in this study. The criteria used in these selection procedures include level of fitness, experience, age and sex to ensure a representative sample of the CF personnel.

On the first day of testing, the scientific background to the study will be outlined in a briefing session. At that time, all procedural details will be explained. Our research group requests that you arrive wearing civilian attire and carry any necessary clothing.

We appreciate your contribution to this project and welcome your questions and comments.

Safety Considerations

See attached sheet.

SAFETY CONSIDERATIONS

1. Please inform the Military Liason of any illness/disability (i.e., diabetes, epilepsy, angina).

2. If you note the signs of Cardiac Stress during the test session, inform your group leader or fellow participant immediately. These signals include:

   i) Heavy pressure, squeezing, fullness, burning, or pain in the centre of the chest.

   ii) Shortness of breath, pallor, sweating, weakness or fatigue.

   iii) Nausea and/or indigestion.

   iv) Apprehension, fear.

3. In the event of illness or injury, stop all activities immediately. Remain calm and await for instructions from the task leader. In the case of injury of one of your fellow participants, the MPFS personnel will attend to their needs. If your help is required you will be asked to perform a specific duty, otherwise please stay clear of the injured person. Finally, if site evacuation is deemed necessary, you will be given instructions by your MPFS task leader. You will exit the Jock Harty Arena by the north doors and the Queen's station by the front entrance of the Physical Education Complex. Any additional information about these safety procedures will be supplied during the briefing session.

PARTICIPANT SCHEDULE

Queen's University, June 1 to August 14, 1987

Monday	13:00	Briefing
	13:30 to 16:30	Queen's Station
Tuesday	8:30 to 12:00	Entrenchment Dig (A)
		Low High Crawl (B)
	12:00 to 13:00	Lunch
	13:00 to 16:30	Entrenchment Dig (B)
		Low High Crawl (A)
Wednesday	8:30 to 12:00	Sea Stretcher Evacuation
	12:00 to 13:00	Lunch
	13:00 to 16:30	Sand Bag Carry
Thursday	8:30 to 12:00	Land Stretcher Evacuation
	12:00 to 13:00	Lunch
	13:00 to 16:30	Subject Repeats

REVISED SCHEDULE

August 3 to August 7

Tuesday	8:30	Briefing
	9:00 to 12:00	Queen's Station
	12:00 to 13:00	Lunch
	13:00 to 16:30	Entrenchment Dig (A)
		Low High Crawl (B)
Wednesday	8:30 to 12:00	Entrenchment Dig (B)
		Low High Crawl (A)
	12:00 to 13:00	Lunch
	1:00 to 16:30	Sea Stretcher Evacuation
Thursday	8:30 to 12:00	Sand Bag Carry
	12:00 to 13:00	Lunch
	1:00 to 16:30	Land Stretcher Evacuation / Subject Repeats

ERGONOMICS RESEARCH LABORATORY

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

Personal Data Summary Sheet

Name:________________________

QUEEN'S STATION:

Incremental Lifting Machine	full reach cm	__________	kg
Flexed Arm Hang		__________	s
Endurance Grip	R	__________	s
	L	__________	s
LOW HIGH CRAWL	total time	__________	s
ENTRENCHMENT DIG	total time	__________	s
LAND EVACUATION	total time	__________	s
SEA STRETCHER EVACUATION	total time	__________	s
SAND BAG CARRY	no. of bags	__________	

INJURY FREE FITNESS

SIX KEY POINTS

Nothing upsets a fitness program like injuries.

You're exercising regularly, [illegible] good progress when suddenly [illegible] a pulled muscle [illegible] sidelines. Sure, you're eager to [illegible] physically and emotionally it can be hard to get going again.

We used to think that the occasional exercise injury was unavoidable. Remember the old saying "No pain, no gain"? But now fitness experts feel that most aches, pains, sprains, and bruises arise when people try to do too much, too soon or too often. Given a sensible program, the majority of exercise injuries are preventable.

To find out the basics of injury free fitness, NETWORK talked to Lynne Cove, supervisor of fitness in the department of recreation at Simon Fraser University in Burnaby, BC, near Vancouver. Lynne brainstormed with her colleagues and some of the folks from the SFU Sports Medicine Clinic and together they developed these six key points for injury prevention.

1

TAKE RESPONSIBILITY FOR YOUR OWN FITNESS

This may not seem much like an injury prevention technique but actually it's one of the most important.

The point is simple: ultimately, only you can tell what's best for you. The classification of different exercises into safe and unsafe is not absolute. Whether any particular exercise is harmful to you depends on your own body and your own level of fitness.

Some people can do any exercise without problems. Others will get aches and pains from activities that are injury free for everyone else. It's up to you to discover your own capabilities and limits. There's no set formula that can be universally applied.

Taking responsibility means:

- Working at your own pace and keeping the intensity of your aerobic activities within your personal target zone
- Listening to your body and easing off on any activity that hurts.
- Balancing your fitness program to ensure that you develop aerobic fitness, muscular fitness, and flexibility.
- Learning and applying fundamental fitness principles.

Bad Moves

"The most common example of someone who doesn't take any responsibility for his own fitness," says Lynne, "is the person who goes up for a fitness class and on the very first day [illegible] and struggles to stay with the leader move for move – never mind that the leader is perhaps a trained dancer or has been working out for years. It's a sure formula for eventual injury. Yes, class participants should certainly follow the leader and work for improvement, but at their own pace and within their own limits.

"The [illegible]

2

FOLLOW THE PRINCIPLE OF PROGRESSIVE OVERLOAD

Progressive overload means two things.

First, it means that to improve fitness you must work your body harder than it is used to – run a little faster or farther, lift a touch more weight, swim a bit longer. It's the extra load you place on your muscles, bones, and cardiovascular system that causes the physiological adaptations we associate with improvement.

That's the *overload* part of it. The *progressive* part simply says that you can't get fit all at once – you have to build up the intensity, duration, and frequency of workouts gradually. Moreover, you have to give your body time to adapt by taking days off from activity or by alternating easier workouts with harder ones. The body needs these breaks to repair itself and recover from the strain of overload. It's this repairing process that leads to new gains.

Without *overload*, fitness can't improve. If overload is not *progressive*, you greatly increase your risk of injury.

Bad Moves

"Seasonal athletes who injure themselves on the very first day of the season are familiar to sports medicine clinics. Typically, these people have forgotten about progressive overload. Going-for-it hockey players are good examples. They may have spent a sedentary summer in a [illegible] league. Their fitness slowly deteriorating. But come their first game in the fall and they go full tilt. Their chances of injury are high. Pre-season conditioning with progressive overload is an essential injury preventive for all sports."

3

VARY YOUR ACTIVITIES

This rule applies to any individual session of activity, or to your whole program. Its aim is to ensure balanced, overall fitness development and to prevent injuries from overuse.

Within any session, activity can be varied in many ways. Swimmers can switch strokes. Runners can speed up and slow down, walk a bit, or jog lightly backwards or sideways. In dancercize you can vary your steps or the way your feet strike the ground. The aim in all cases is to spread the stress of activity over a broader range of muscles.

Within a program, varying activities ensures development of all muscle groups and gives particular muscles a chance to rest and adapt while others are working. For example, if you cycle one day and swim the next, you alternate between using the muscles of the lower and upper body. Hence you get balanced development and avoid injuries caused by using the same muscles workout after workout.

Bad Moves

"The classic bad examples here are compulsive runners – people who go out day after day for the same ten kilometers and sooner or later run themselves right into a serious injury. Lately, however, we're seeing more and more lower leg injuries among dancercisers – people who subject their legs to a steady and very stressful diet of hopping, skipping, and jumping. Like running, this form of exercise puts a lot of stress on the lower legs. It's good, common sense prevention to alternate dancercize with upper body activities like swimming or rowing, or weight-supported activities like cycling."

4

STAY WITHIN THE NORMAL RANGE OF MOTION OF YOUR JOINTS

The action that bends a joint is called flexion. The action that straightens out a joint is called extension. It's important to exercise joints through their full range of motion. This helps to keep them well lubricated, mobile, healthy and strong.

However, it is possible to push joints *past* their normal range of motion, to either *hyperextend* or *hyperflex* them. This is when injuries occur. Outside its normal range, a joint no longer has the support and protection of surrounding muscles. This puts potentially injurious stress on the ligaments which hold bones together at joints.

One of the easiest ways a joint can be pushed too far is by *ballistic* motion, motion in which a limb or part of the body is thrown into motion, rather than being moved under control of the muscles. Momentum then pushes the joint past its normal range.

Bad Moves

"A knee which is bent more than ninety degrees is past the point at which it has adequate muscular support. If at the same time it must carry a load – as in deep knee bends, squats, and standing stretches for the inside of the thigh – there is a risk of injury. In all such exercises the knee should be bent no more than ninety degrees.

"Many common exercises – full trunk circles, for example – hyperextend the joints of the spine and neck by bending them backwards. When this happens the vertebrae can squeeze the vertebral discs, causing sudden injury which may lead to long term deterioration.

"Hyperflexion of the spine, extreme forward bending, can also be dangerous if done incorrectly. The most common dangerous exercise is the standing, straight legged toe touch, which bends the lower back past the point where it has muscular support while at the same time forcing it to carry the weight of the upper body against the skewing force of gravity. The risk is increased when ballistic bouncing is done in this position. It's best to do this exercise from a sitting position so that the spine does not have to carry such a heavy load. If you do it while standing, you should be sure to keep your knees bent, which gives your lower back more muscular support."

5

MAINTAIN PROPER POSTURE

In good posture the parts of your body are lined up so that you can move or hold yourself erect with the least possible effort and strain. In good posture the neck is held straight, the pelvis is tilted and tucked in, the curvature of the lower back is minimized, the knees are centred over the feet, and the centre of gravity of the body is held over the base of support. It's as if your whole body were hanging straight down from a thread attached to the top of your head.

Bad static posture, standing or sitting, is associated with many chronic problems, such as lower back pain. Bad dynamic posture – that is, poor alignment of the body in motion – is a significant cause of injury. When the body in motion is not well aligned, strong twisting and ballistic forces can be generated which carry joints past their normal range of motion or throw the body dangerously off balance. To prevent injury, therefore, it's important to be aware of postural principles and apply them while exercising.

Bad Moves

"One type of exercise which causes injury because of poor alignment is jumping and hopping dance steps, especially those with a lot of sideways or twisting motion. It's how you land that's critical. You should come down with your knees squarely over your toes and your feet and thighs pointing in the same direction. If you don't, you are applying a potentially injurious twisting force to your knees.

"Pelvic tilt is an essential postural component of many exercises. It is often ignored in leg raises from an all fours position. Keeping your pelvis tilted during such exercises ensures that you don't hollow your back and maintains lower back support."

6

WARM UP AND COOL DOWN

A good warm-up includes activities that slowly raise your heart rate, that flex and relax muscles and that move joints through a broad range of motion. It prepares your body for activity. It lubricates your joints, gets your muscles ready for greater energy output by increasing their blood supply, and makes both muscles and connective tissues more supple in preparation for vigorous activity. A body thrown suddenly into activity without a good warm up is working against its own internal stiffness and resistance, and that causes injuries.

Cool downs after activity are important, too. After vigorous activity your muscle cells contain many waste products which must be flushed away. A cool down is a slow tapering off of activity that keeps heart rate and blood flow from dropping off too quickly.

Bad Moves

"Warm ups and cool downs are that part of a work out most often sacrificed when people are on a tight schedule. How many times have you seen someone come out of the locker room at a run and jump straight into a fitness class or basketball game without even a token warm up. This is asking for trouble. Ideally we should all try to schedule things so that we have enough time to warm up and cool down properly. If you can't do that, it's best to steal a few minutes from some other part of your routine instead of skipping warm up and cool down completely.

Many people still stretch to warm up. This isn't a good idea. A cold muscle is relatively inelastic and trying to stretch it not only doesn't warm it, but can actually cause injury. The rule is: warm up first, then stretch.

PARTICIPaction NETWORK

Warm-up

Definition. The first phase of an exercise session is the warm-up. This 5-to-10-minute session should activate the physiological systems in preparation for the more vigorous exercise to come.

Importance. There are a number of important reasons for including a warm-up in an exercise prescription. First, you should be mentally prepared for the exercises that are to follow, just as the elite athlete works hard, mentally as well as physically, prior to competition in order to perform his or her best. Further, increasing your body temperature by warming up reduces the incidence of injury to muscles and joints in subsequent strenuous exercise. The warm-up should also be designed so that it stretches out your muscles and allows your joints to move through their complete range of motion.

Prescription Principles. This phase of the exercise session should range from a light to a moderate level of intensity. The session should be divided into two parts: aerobic activities and stretching exercises.

1. The aerobic activities should be of low intensity, their speed and frequency dependent on your fitness level. The activities should be sufficient only to increase body temperature to the point where you feel warmer; any sweating at this point will be the result more of environmental conditions than of the activity itself (see Chapter 5).
2. The stretching exercises should be performed slowly and carefully. Select exercises that stretch all of the major joints and muscle groups of the body through their natural range of motion. Each exercise should be performed rhythmically (avoid bobbing and jerking) up to ten times. Or, if you prefer, hold the stretch position for 10 to 20 seconds, and repeat up to 5 times.

Prescription. The following aerobic and stretching exercises for the warm-up phase are only suggestions. The first is a normal warm-up for the less physically fit; the second is more suitable for active, physically fit people. The exercises may be replaced, modified, or expanded to include skipping, swimming, or some other activity, as long as the objectives for warm-up exercises are met.

Example of Aerobic Warm-up. The most common aerobic warm-up is a sequence of slow walking — walking — brisk walking — jogging — steady running etc. However, a number of other innovative warm-ups can be developed, depending upon the facilities. In the house, for example, the following sequence is possible: walking up 1 to 5 flights of stairs (walk down) — slow running up stairs (walk down) — continuous two-leg jumping up stairs (walk down) — etc. Similar warm-up sequences can be devised for mediums such as water and snow.

Specific Flexibility Exercises. *Do not* overstretch—these are warm-up exercises.

For the Neck:

Exercise 1: Neck Rotator. Keeping the eyes focused forward and holding the chin in toward the neck, move the head slowly in a circular pattern, first in one direction and then in the other (Figure 8.2a). (Stretches neck *rotators*—flexors and extensors.) *Note:* If you have neck problems, avoid these exercises unless you are directed to perform them by a physician.

Exercise 2: Neck Twists. Turn the face slowly to the left and then to the right; repeat several times (Figure 8.2b). Stretches neck rotators—flexors and extensors.)

For the Trunk:

Exercise 1: Twister. Standing with feet apart and arms abducted sideways, twist to the left with arms and face moving in the same direction (Figure 8.3), and then twist to the right. Repeat slowly and rhythmically 5 to 20 times. (Stretches neck and trunk rotators.)

Exercise 2: Side Bender. Standing with feet apart and hands on head, bend slowly from side to side in the frontal plane (Figure 8.4). Repeat 5 to 10 times. (Stretches lateral benders of trunk.)

Exercise 3: Front Bends. Standing with feet together (Figure 8.5a), fully flex the neck, trunk, and hips and slightly flex the knees (Figure 8.5b). Extend, and repeat 5 to 10 times. (Stretches trunk, neck, and hip extensors.)

For the Legs:

Exercise 1: Hamstring Stretcher. Sitting on the floor with legs straight and spaced, reach for one ankle and hold; do the same with the other ankle (Figure 8.6). Repeat 5 to 10 times. (Stretches hip extensors and knee flexors.)

Exercise 2: Lateral Stretcher. Standing with legs wide apart and hands on hips, bend left leg and move body weight to the left; hold, and then shift weight over to the other foot (right knee bent) (Figure 8.7). Repeat 5 to 10 times. (Stretches hip adductors.)

Exercise 3: Front Stretcher. Keep hands on hips. Placing one leg (knee bent) well forward of the other (Figure 8.8) and keeping the other leg straight with ankle dorsiflexed, slowly move forward and hold for several seconds. Repeat 5 to 10 times for both sides. (Stretches the hip flexors, knee extensors, and ankle dorsi flexors.)

For the Shoulders:

Exercise 1: Arm Circles. Standing with feet apart, perform slow, full-arm circles backward 5 to 10 times, then forward the same number of times. The arms should brush past the ears and the sides of the trunk (Figure 8.9). (Stretches the muscles crossing the shoulder joints.)

Exercise 2: Pull-Throughs. Standing with feet apart, flex one arm (straight) forward to shoulder level, extend the other arm backward to shoulder level, then swing both arms down and through so that they reverse positions (Figure 8.10). Repeat rhythmically 10 to 20 times, gradually increasing the vigor of the

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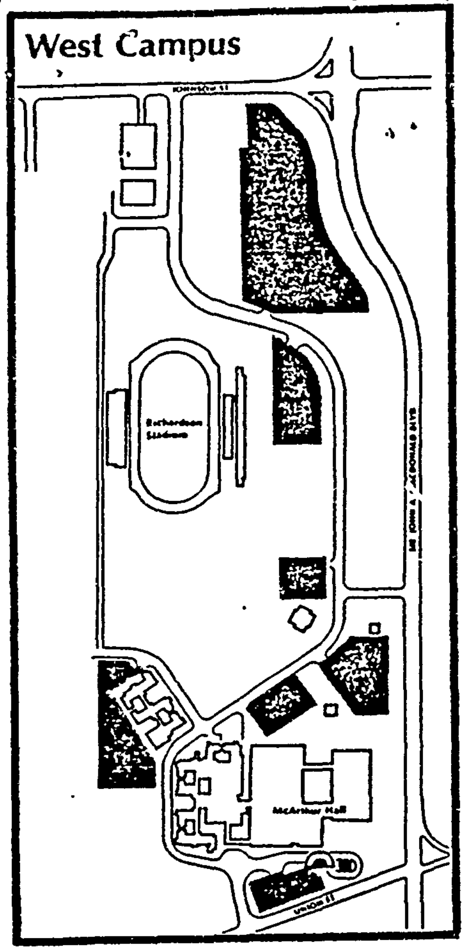
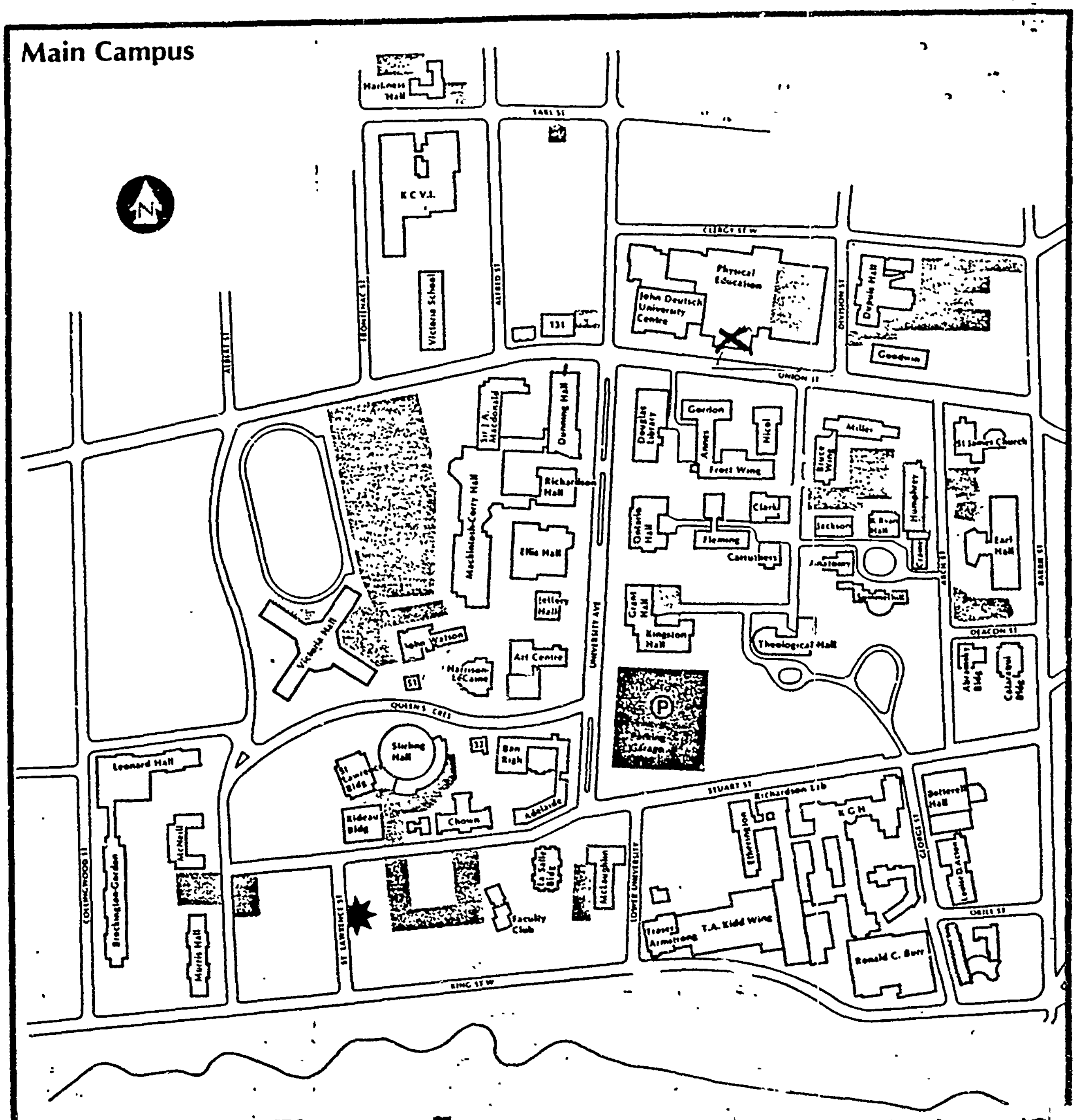
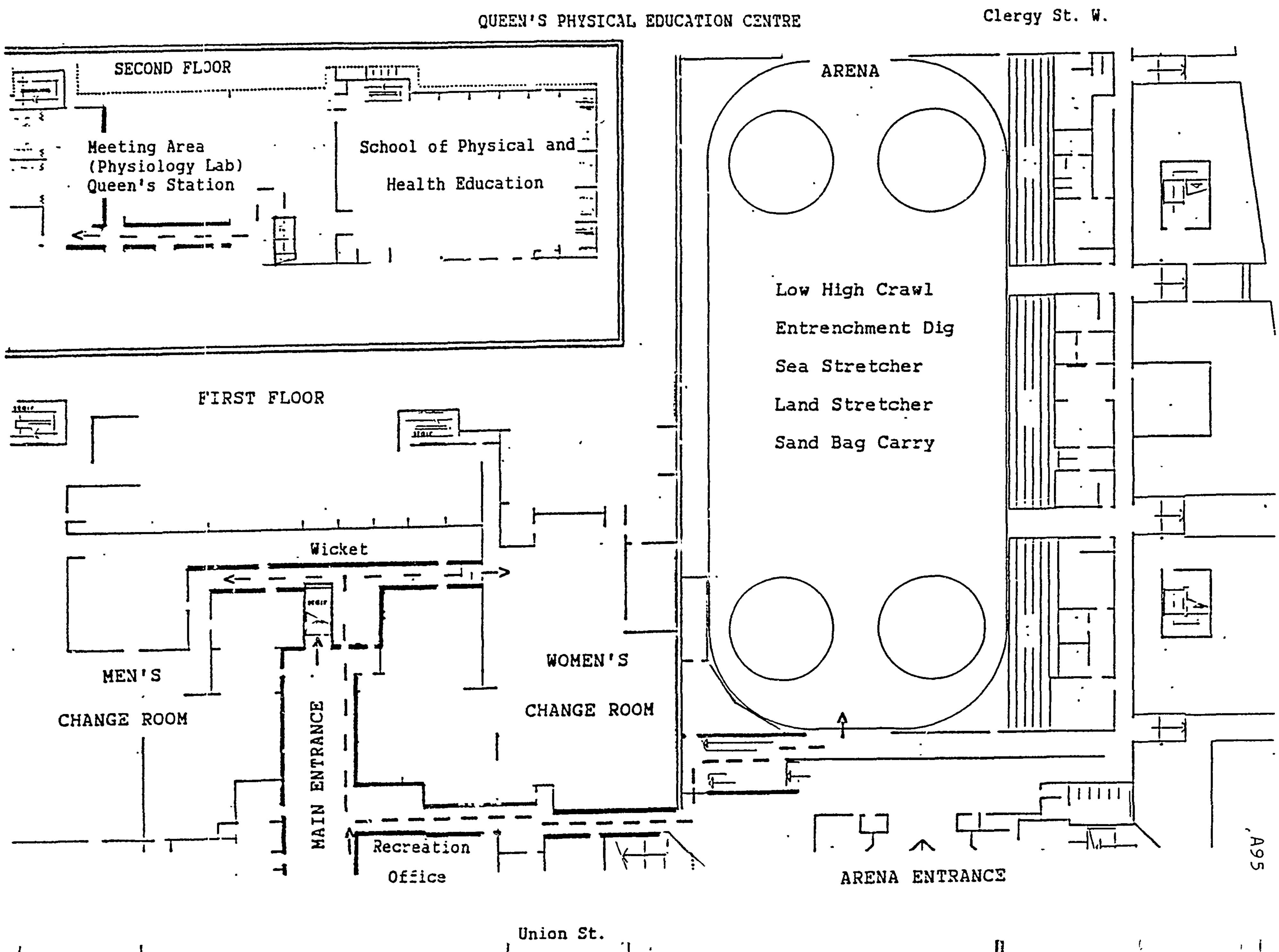




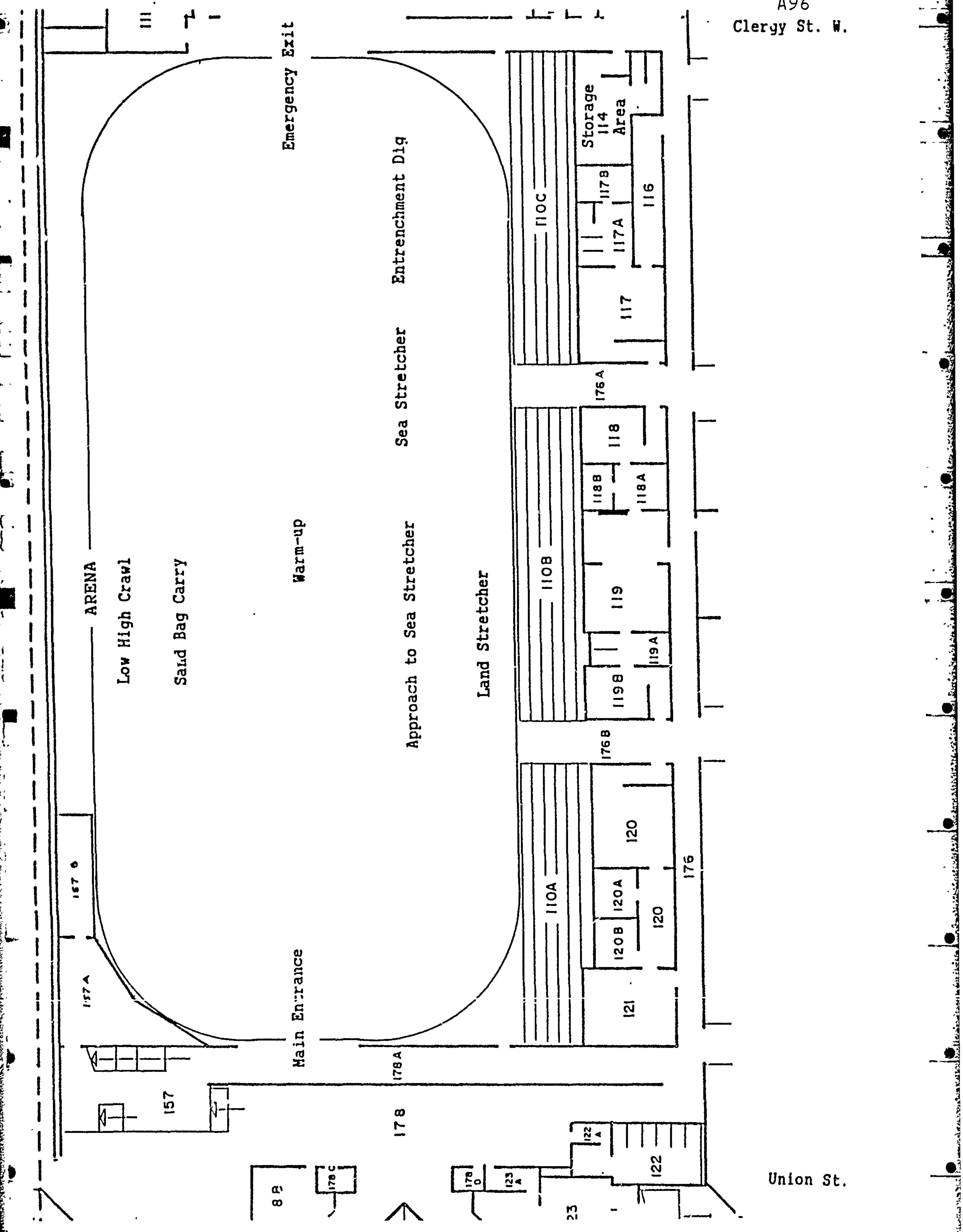
Parking Lot Locations

Key

- Surface Parking (Red Stickers)
- West Campus (Gold Stickers) permits are valid on the West Campus ONLY
- Parking Garage (White Stickers) permits are valid in the Parking Garage ONLY
- (P) Short Term Parking
- Parking Meters
- P... O...



QUEEN'S PHYSICAL EDUCATION CENTRE
Clergy St. W.
SECOND FLOOR
Meeting Area
(Physiology Lab)
Queen's Station
School of Physical and
Health Education
ARENA
Low High Crawl
Entrenchment Dig
Sea Stretcher
Land Stretcher
Sand Bag Carry
FIRST FLOOR
Wicket
MEN'S
CHANGE ROOM
WOMEN'S
CHANGE ROOM
MAIN ENTRANCE
Recreation
Office
ARENA ENTRANCE
Union St.


Clergy St. W.
Emergency Exit
Entrenchment Dig
Sea Stretcher
Warm-up
ARENA
Low High Crawl
Sand Bag Carry
Approach to Sea Stretcher
Land Stretcher
Main Entrance
Storage 114 Area
111
110C
110B
110A
116
117
117A
117B
118
118A
118B
119
119A
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120
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122 A
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176A
176B
157
157A
157 B
178
178A
178C
178 D
8B
Union St.