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

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

DSS/DND Contract #01SE.W7711-6-9053
DEFENCE & CIVIL INSTITUTE FOR ENVIRONMENTAL MEDICINE

Joan M. Stevenson, Ph.D.
George M. Andrew, Ph.D.
J. Timothy Bryant, Ph.D.
John M. Thomson, Ph.D.
Sheryl L. French, M.A.
Leslie L. Langley, MSc.

DEVELOPMENT OF MINIMUM PHYSICAL FITNESS STANDARDS FOR THE CANADIAN ARMED FORCES: PHASE II

submitted by

SCHOOL OF PHYSICAL AND HEALTH EDUCATION
DEPARTMENT OF MECHANICAL ENGINEERING

QUEEN'S UNIVERSITY AT KINGSTON

Joan M. Stevenson, Ph.D.
George M. Andrew, Ph.D.
J. Timothy Bryant, Ph.D., P.Eng.
John M. Thomson, Ph.D.
Sheryl L. French, M.A.
Leslie L. Langley, M.Sc.

to

DEFENCE AND CIVIL INSTITUTE FOR ENVIRONMENTAL MEDICINE

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Scientific Authority: Dr. W.S. Myles

PREFACE

This study was undertaken to continue development of physical fitness standards commensurate with satisfactory performance of identified common military tasks. In the present phase, MPFS II, several of the common tasks were, with permission of the CF, substantially modified in order to improve the predictability of (task) performance based upon subject's physical fitness. The standard measures of physical fitness selected which could best predict task performance included CF EXPRES test battery, standard laboratory measures of physical fitness, and the Incremental Lifting Machine (ILM).

At CFB Borden, 50 male and 24 female CF personnel under 35 years of age, were observed performing the following common military tasks: Land Stretcher Carry, Sea Stretcher Evacuation, Low-High Crawl, Entrenchment Dig Task and the Sandbag Carry. At CFB Uplands in Ottawa, 62 males and 72 females also completed this battery of tasks, however, 41 of these male subjects and 8 females were over 35 years of age in this sample population.

Correlations between EXPRES measurments and standard laboratory measurements indicated EXPRES to be a reasonable measure of general physical fitness. Physiological measurements suggested that the five tasks examined had substantial fitness components. However, it was not possible to predict performance in these tasks from fitness measurements alone.

In order to establish minimum fitness standards, an empirical model was developed. This model gave scores for fitness variables found to be components of task performance.

First, task performance times which 75% of the sample achieved achieved were used to define a "passer" group.This enabled minimum fitness standards to be set as the level achieved by 95% of the passers in any given subject group. It was not possible to determine MPFS values by those calculated for females $\geq$ 35 years because of the small number of subjects in this group.

It is recommended that the EXPRES protocol continue to be developed and improved as a measure of physical fitness in the CF, and that minimum fitness standards be established for military personnel based upon task performance. It is recommended that the empirical model for males < 35 years be adopted by the CF based upon two years of study, MPFS I and II, the current MPFS recommendations. As well, it is recommended MPFS values for females < 35 years and males $\geq$ 35 years be adopted pending appropriate validation studies (presently being planned).

A further qualification is emphasized regarding MPFS for males $\geq$ 35 years. During testing, for safety reasons, these subjects were not permitted to exceed 90% of their predicted maximum heart rate reserve; this safety limit having been constantly monitored and enforced throughout task performance. Therefore, a separate pilot study, employing volunteers over 35 years who are permitted to work at maximal intensity, should be undertaken in order to determine what influence, if any, the restrictions had on the MPFS determinations for this group.

Finally, it is further recommended that a study be undertaken to establish MPFS standards for females $\geq$ 35 years.

In this report, Section A presents the summary of our findings from all aspects of the study. Included are essential descriptions of objectives and work plan, task selection, experimental protocol, methods, results, and statistical analyses. Also included in the Summary Report is a discussion of limitations of the study, evaluation of the common military tasks, recommendations for EXPRES, and implications of the empirical model approach. Conclusions and Recommendations of the study are summarized in Section A5. Detailed experimental reports are contained in Section B. In each section, the individual experiments (i.e., tasks) are described fully with documentation regarding protocol, results, and analysis. These reports describe the fitness measurements performed, each of the five tasks studied, and psychological profiles of subjects prior to, then following testing. The final sections of the report include appendices which document much of the raw data collected during the study.

This project was truly a team effort. I wish to acknowledge the impetus and guidance of Dr. Stewart Myles (DCIEM) and Majors Wayne Lee and Winson Morrison. In addition, personnel from CFB Borden and Uplands were very helpful and supportive during data collection. Daily contract management was under the capable leadership of Sheryl French in conjunction with research assistants Jennifer Williams, Marcia Thomson, Mary Byrnes and Kristen Thomson. I also wish to thank two colleagues, Dr. Lise Gauvin and Dr. John Albinson, who have contributed greatly to the project in terms of the psycological assesment of subjects.

J.M. Sevenson, Ph.D
March 31, 1987

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SECTION A

THE SUMMARY REPORT

A1 INTRODUCTION

A1.1 Summary of Work to Date

This contract represents an extension of earlier research (MPFS I) conducted in 1985 by the Queen's University Ergonomics Laboratory. In the present contract, Canadian Forces personnel were tested for physical fitness and in the performance of common military tasks. A primary objective was to standardize the measurement of performance in these tasks to permit assessment of the relationship between fitness measures and task performance.

In preliminary studies at Queen's University, the protocols for eight tasks were fully developed including the design and testing of specialized equipment required for standardizing the tasks. In addition, protocols for EXPRES and other laboratory measures of fitness were evaluated. These are indicated in Table A1.

Testing was undertaken on CF personnel at CFB Borden and CFB Ottawa. Subject distribution by gender and age is indicated in Table A2. By design, testing protocol for subjects $\geq$ 35 years required that no one work at a rate greater than 90% of their maximal capacity. Consequently, this necessitated that, in the analysis of their performance of all tasks and fitness measurements, cognizance be taken of this imposed restriction.

A1.2 Scope of this Final Report

Section A summarizes the major results of correlation between EXPRES fitness measures and task performance.

In the main, four tasks are considered in this report.

Table A1.

Identification of 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* 6. Incremental Stretcher Carry*
Fitness Tests	1. EXPRES test i) grip strength ii) oxygen consumption iii) pushups iv) situps 2. Flexed arm hang 3. ILM - 1.83 m 4. ILM - 1.52 m 5. Arm Ergometer** 6. Leg Ergometer**

* Only subjects at CFB Borden completed these tasks.

** Subjects $\geq$ 35 years of age did not perform these tasks.

Table A2.

Distribution of CFB Borden and CFB Ottawa by age and sex.

Site	Under 35 years (n)	Over 35 years (n)	Total
CFB Borden			
Men	50	--	50
Women	24	--	24
CFB Ottawa			
Men	21	41	62
Women	64	8	72
Total	159	49	208

These are Low High Crawl, Land Evacuation, Sea Evacuation and Entrenchment Dig. The Sand Bag Carry Task is also discussed in Section B; and where appropriate, discussions of other fitness measures and task performances are presented. The main conclusions derived from this report are those concerning recommendations for minimum EXPRES scores required by CF personnel in order to meet reasonable task performance levels.

The individual data for each fitness test and emergency task are reported in Sections B1-B7. Following, in Sections C through H, the individual subject data, details of the various testing protocols, safety procedures for the study, handouts given to subjects, and other material relevant to the present study are presented.

A2 DESCRIPTIVE RESULTS

A2.1 Physical and Anthropometric Variables

The description of all results is divided by age and gender as indicated in Table A3. Anthropometric variables include age, height and weight; their distribution conforms to those observed in Canadian and Military populations. A significant difference is noted between height and weight variables across gender, though not in regard to age.

A2.2 EXPRES Tests

A summary of EXPRES variables by gender is shown in Table A4. Predicted aerobic capacity varied both by age and by gender as indicated by subjects' VO_2 max values. Combined grip showed marked male/female differences and age related relationship for females only. Pushups did not differ between gender nor by age; however it should be noted that the pushup protocol performed was different for men and women and this had a direct effect on performance of this test. Finally, no age or gender variation in number of situps was observed.

In order to describe the sample population in terms of military normative data, EXPRES percentiles for subjects tested are shown in Table A5. In general, a reasonable distribution of subjects from excellent to poor categories is evident. Among exceptions to this trend were men under 35 years who tended to be below average in predicted VO_2 max. Women under 35 years had lower than average combined grip scores. Men above 35 years were

Table A3.

Summary of Physical Characteristics of C.F. Personnel.

	AGE (yrs)	HEIGHT (cm)	WEIGHT (kg)
Men < 35 years			
Mean	23.9	176.7	76.8
S.D.	5.5	6.3	11.2
(min-max)	17-34	164-195	56-106
Men ≥ 35 years			
Mean	39.9	176.1	81.2
S.D.	3.9	5.9	10.0
(min-max)	35-47	164-192	61-103
Women < 35 years			
Mean	24.7	163.4	62.2
S.D.	3.8	5.9	9.1
(min-max)	(18-34)	(152-178)	(44-88)
Women ≥ 35 years			
Mean	36.5	166.0	61.7
S.D.	1.0	6.7	10.8
(min-max)	(35-38)	(156-174)	(44-80)

Table A4.

Summary of EXPRES Variables by Sex and Age Level.

	VO_2MAX ml/kg/min	Comb. Grip kg	Pushups #	Situps #/min
Men < 35 years				
Mean	47.9	99.4	30.0	36.6
S.D.	5.1	16.1	10.1	9.3
(min-max)	37-58	53-137	9-59	21-71
Men ≥ 35 years				
Mean	41.7	106.6	30.7	37.0
S.D.	4.6	19.4	11.0	7.8
(min-max)	32-56	66-145	7-60	20-52
Women < 35 years				
Mean	37.1	58.7	33.9	35.0
S.D.	4.3	10.3	10.3	10.5
(min-max)	23-56	31-89	10-61	11-70
Women ≥ 35 years				
Mean	35.6	74.1	28.6	31.8
S.D.	3.4	41.4	11.7	6.1
(min-max)	31-41	37-170	15-45	24-41

Table A5. Population Distribution by EXPRES Percentiles based on military Normative data. Values indicated are the counts observed in each category.

Test Variables	< 35 Years		≥ 35 Years	
	Men	Women	Men	Women
OXYGEN CONSUMPTION (ml/kg/min)				
Excellent	7	18	7	2
Good	6	11	6	3
Average	17	23	11	1
Below Average	20	18	8	0
Poor	17	15	11	2
COMBINED GRIP (kg)				
Excellent	6	7	11	2
Good	14	8	7	0
Average	16	10	6	3
Below Average	10	29	9	1
Poor	16	25	8	2
PUSHUPS (no.)				
Excellent	4	20	18	3
Good	12	21	10	0
Average	15	9	4	1
Below Average	14	19	6	3
Poor	18	14	3	1
SITUPS (no.)				
Excellent	12	23	15	2
Good	14	11	12	1
Average	19	17	5	4
Below Average	7	13	4	1
Poor	10	15	2	0

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

above average in performance for pushups and situps.

A2.3 Laboratory Tests

A summary of laboratory tests for men by age level is presented in Table A6a. While data were available for men under 35, men over 35 were not permitted to perform those tasks requiring maximal effort (i.e., arm and leg ergometry tests). The differences in the other tests (i.e., ILM Lifts, Flexed Arm Hang and Endurance Grip) were not significant.

Results of laboratory tests for women (Table A6b) showed no significant age related differences. For Endurance grip there was a large though not significant difference between younger and older women owing to the small sample of ≥ 35 women. Differences in scores between males and females are also evident. The test scores for men were greater than for women in all measurements.

A2.4 Field Tests

Results of all field tests, including the lifting and carrying tasks, are summarized in Table A7a for men by age level. Time for task performance was the basis on which comparisons were made (see individual B sections). Note that it was not possible to compare the performance of younger and older individuals since the test criterion for subjects ≥ 35 limiting work intensity to 90% maximal capacity was applied to this age group; statistically, therefore, these were be viewed as performance measurements for different tasks. While this limitation is evident for Low High Crawl, Entrenchment Dig, and Sea Evacuation, the Land Evacuation task was performed by men ≥ 35 in less time.

Table A6a.

Summary of Laboratory Tests for Men by Age Level.

Test Items	< 35 Years Mean	SD	(min-max)	≥ 35 Years Mean	SD	(min-max)
ILM TEST 6' (kg)	46.7	9.8	30-85	45.1	7.9	30-60
ARM ERGOMETER						
Total Work (KJ)	8.0	1.8	6-18	N.A.		
Peak Power (W)	261.1	52.6	178-599	N.A.		
Drop off (%)	46.1	8.9	29-65	N.A.		
LEG ERGOMETER						
Total Work (KJ)	17.2	2.6	12-23	N.A.		
Peak Power (W)	728.9	118.8	498-1055	N.A.		
Drop off (%)	42.4	8.8	25-57	N.A.		
FLEXED ARM HANG (s)	42.9	17.4	5-100	38.2	13.5	12-67
ENDURANCE GRIP (s)	169.5	85.6	44-437	265.8	110.9	93-577

Table A6b.

Summary of Laboratory Tests for Women by Age Level.

Test Items	< 35 Years Mean	SD	(min-max)	≥ 35 Years Mean	SD	(min-max)
ILM TEST 6' (kg)	23.8	5.2	15-43	22.5	4.2	18-28
ARM ERGOMETER						
Total Work (KJ)	3.7	0.5	3-5	N.A.		
Peak Power (W)	122.2	24.4	48-183	N.A.		
Drop Off (%)	44.3	9.8	22-67	N.A.		
LEG ERGOMETER						
Total Work (KJ)	11.2	1.7	8-14	N.A.		
Peak Power (W)	487.7	83.9	301-706	N.A.		
Drop Off (%)	40.7	9.4	13-60	N.A.		
FLEXED ARM HANG (s)	15.8	13.3	0-63	21.7	14.8	5-48
ENDURANCE GRIP (s)	70.8	41.0	3-210	147.6	82.5	33-231

Table A7a.

Summary of Field Tests for Men by Age Level.

	Men < 35 years			Men ≥ 35 years		
	Mean	SD	(min-max)	Mean	SD	(min-max)
Land Evacuation						
Time to 1 km (s)	782.9	237.0	379-1451	750.6	174.8	444-1145
Low High Crawl						
Low Crawl Time (s)	42.0	11.2	26-73	59.3	23.9	26-135
High Crawl Time (s)	41.1	8.6	25-71	53.9	15.3	30-109
Total Time (s)	83.1	17.5	53-125	113.2	35.0	56-212
Entrenchment Dig						
Total Time (s)	252.7	50.2	161-436	358.1	113.1	214-690
Sea Evacuation						
Total Time (s)	51.4	29.1	21-229	74.9	45.7	26-227
Sandbag Carry						
# Bags	17.3	1.7	14-21			
m/s	2.9	0.3	2.3-3.5			
Incremental Stretcher Carry						
Phase 1	69.8	10.1	56-97			
Phase 2	90.0	16.0	64-128			
Phase 3	108.3	37.6	73-304			
Phase 4	137.3	53.9	84-321			

Field test results for women by age level are shown in Table A7b. No age based differences in performance are evident. In general, womens' performances were significantly poorer than mens' performances when comparing the means of the two groups. Of note are the large standard deviations for all of the mean values. As a consequence of this, the distributions of performance scores for both sexes reflects the large range of abilities in executing the tasks.

Table A7b.

<u>Summary of Field Tests for Women by Age Level</u>.

	Women < 35 years			Women > 35 years		
	Mean	S.D.	(min-max)	Mean	S.D.	(min-max)
Land Evacuation						
Time to 1 km (s)	1173.3	415.0	0-2754	1146.3	342.0	747-1796
Low High Crawl						
Low Crawl Time (s)	79.0	26.9	34-163	99.6	45.0	71-179
High Crawl Time (s)	60.8	16.3	31-152	66.8	15.1	52-92
Total Time (s)	139.8	39.1	73-315	116.4	58.8	131-271
Entrenchment Dig						
Total Time (s)	510.8	134.0	273-993	590.3	183.7	364-944
Sea Evacuation						
Total Time (s)	160.5	105.3	41-446	116.0	65.6	53-184
Sandbag Carry						
# Bags	13.1	1.4	10-15			
m/s	2.2	0.2	1.7-2.5			
Incremental Stretcher Carry						
Phase 1	114.5	32.2	84-203			
Phase 2	149.8	37.9	103-256			
Phase 3	206.7	114.8	103-670			
Phase 4	256.3	87.3	126-451			

A3 INFERENTIAL RESULTS

A3.1 Introduction

Theoretically, an ideal situation would evolve if it were possible to directly correlate fitness measurements to task performance. As indicated in previous contracts and in the literature generally, this is not possible. In order to meet the objectives of the contract, however, a rational approach must be taken in order to develop appropriate purposed minimum physical fitness standards for the CF. The approach taken and the statistical procedures applied are indicated in Figure A1.

First, simple correlation between all fitness parameters and all military task scores were computed. As a result of this any significant correlations, whether or not highly predictive, were indicated. In the next step, multiple linear regression models were produced to link together several fitness parameters in predicting single task performances. Parameters which appeared in such regressions are appropriate for establishing fitness standards. Finally, an empirical model was developed according to a series of steps. [redacted] achieve. Having established this performance criterion, the sample population was divided into passers and failers for each task.

Using the previous analysis, fitness variables associated

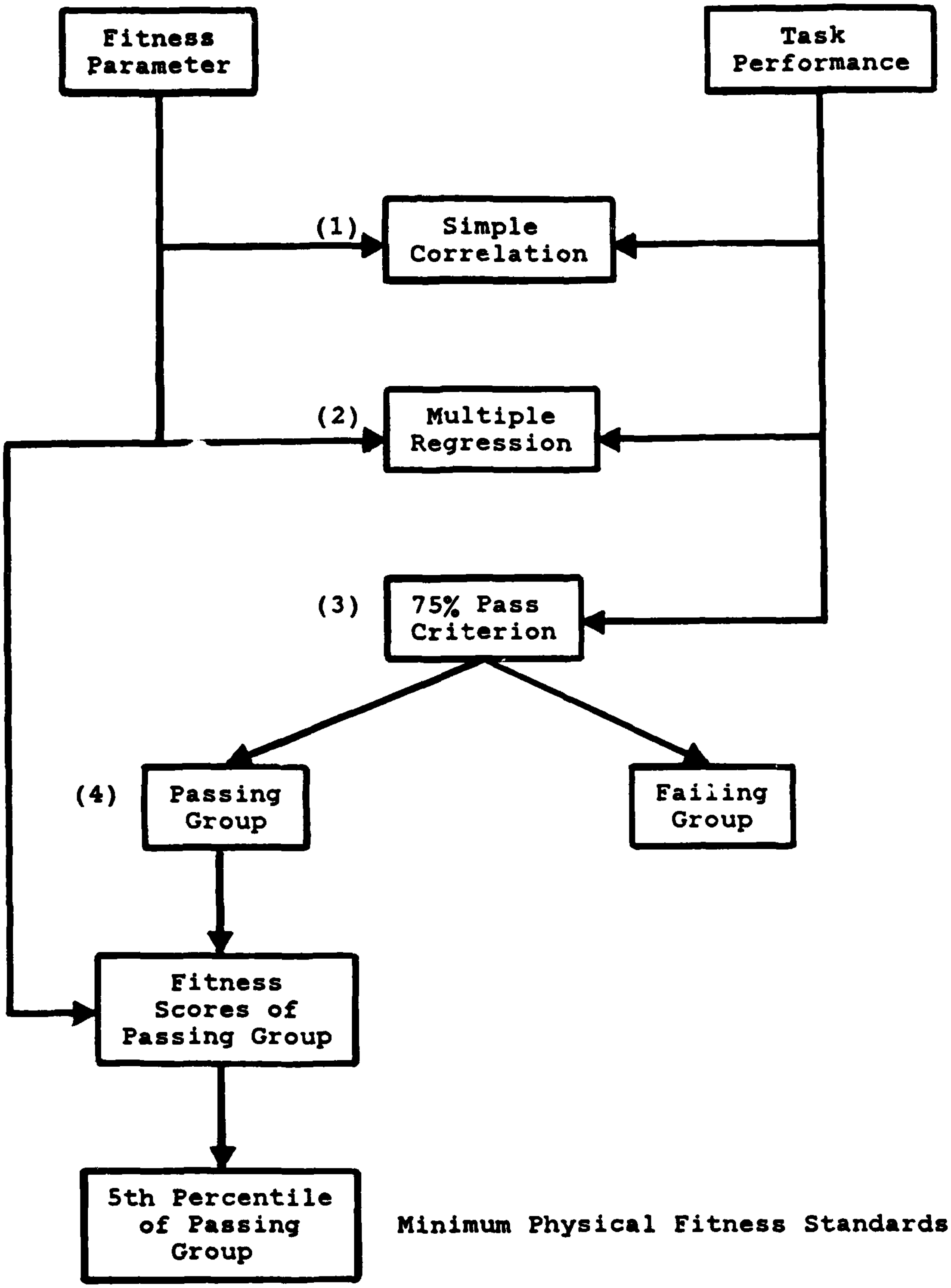


Figure A1 Flow diagram of inferential results used in the development of Minimum Physical Fitness Standards.

with significant simple correlations or multiple linear regressions were included in the empirical model. Means and standard deviations for all passers on an individual task were accumulated for each of these fitness parameters. Finally, fifth percentiles for these distributions were determined. This gave the minimum fitness standard for performance of that particular task. By repeating this procedure for all tasks, evolution of fitness standards to ensure adequate performance in all tasks was possible.

A3.2 Simple Correlation

Simple correlations between performance measures and selected fitness components are shown in Table A8. Fitness measures are subdivided by classification: anthropometry, strength and endurance, aerobic capacity, and anaerobic capacity. Correlations for young men are shown in Table A8a. In section A of this report, only EXPRES fitness parameters and the tasks of Land Evacuation, Low High Crawl, Entrenchment Dig and Sea Evacuation are considered. Generally, no single variable could account for more than 50% of the variance for the task scores.

The correlation between performance measures and fitness components for young women is shown in Table A8b. Again, no variable could account for more than 50% of the variance in performance scores. Similar observations were made for the older male population (Table A8c), however, insufficient numbers precluded the tabulation of similar results for the older female populations.

Table A8a.

Correlations (r) Between Performance Measures and Selected Fitness Components for Men < 35 Years.

Fitness Parameters	Land Evac.	Low High Crawl	Entrench-ment Dig	Sea Evac.
1. ANTHROPOMETRY				
Age	-.18	-.20	-.24	.30
Height	-.20	-.38	-.41	-.34
Weight	-.24	.11	-.15	.04
2. STRENGTH AND ENDURANCE MEASURES				
Max. Grip (weight)	-.16	-.17	-.17	-.14
Combined Grip	-.39	-.13	-.33	-.24
Endurance Grip	-.49	-.17	-.23	-.21
Flexed Arm Hang	-.24	-.51	-.13	-.20
Situps	-.21	-.18	.03	-.09
Pushups	-.33	-.39	-.03	-.20
ILM Lift to 183 cm	-.25	-.23	-.33	-.15
ILM Lift to 152 cm	-.30	-.21	-.39	-.13
3. AEROBIC CAPACITY				
Step Test	-.06	-.27	-.29	-.18
4. ANAEROBIC CAPACITY				
A. Lower Body				
Total Work	-.29	-.02	-.42	-.22
Peak Power	-.20	.08	-.31	-.11
% Drop Off	.20	.25	.14	.21
B. Upper Body				
Total Work	-.24	-.05	-.24	-.20
Peak Power	-.24	-.05	-.24	-.20
% Drop Off	.16	.13	.22	.33

Table A8b.

Correlations (r) Between Performance Measures and Selected Fitness Components for Women ≤ 35 Years.

Fitness Parameters	Land Evac.	Low High Crawl	Entrench-ment Dig	Sea Evac.
1. ANTHROPOMETRY				
Age	-.10	.16	.13	.18
Height	-.24	.02	-.08	-.26
Weight	-.12	.32	-.17	-.32
2. STRENGTH AND ENDURANCE MEASURES				
Max. Grip (weight)	-.09	-.36	-.06	-.16
Combined Grip	-.19	-.23	-.25	-.45
Endurance Grip	-.22	-.35	-.35	-.24
Flexed Arm Hang	-.13	-.59	-.34	-.23
Situps	-.06	-.53	-.23	-.04
Pushups	-.06	-.52	-.40	-.24
ILM Lift to 183 cm	-.25	-.21	-.28	-.24
ILM Lift to 152 cm	-.30	-.26	-.37	-.27
3. AEROBIC CAPACITY				
Step Test	-.02	-.40	-.17	-.18
4. ANAEROBIC CAPACITY				
A. Lower Body				
Total Work	-.28	-.26	-.48	-.57
Peak Power	-.25	-.12	-.40	-.36
% Drop Off	-.001	.18	.03	.25
B. Upper Body				
Total Work	-.32	-.23	-.48	-.47
Peak Power	-.32	-.23	-.48	-.47
% Drop Off	-.14	.14	-.07	.03

Table A8c.

Correlations (r) Between Performance Measures and Selected Fitness Components for Men > 35 Years.

Fitness Parameters	Land Evac.	Low High Crawl	Entrenchment Dig	Sea Evac.
1. ANTHROPOMETRY				
Age	-.18	.13	.22	.13
Height	-.20	-.02	-.06	-.15
Weight	.03	-.15	-.12	-.20
2. STRENGTH AND ENDURANCE MEAURES				
Max. Grip (weight)	-.03	-.26	-.05	.06
Combined Grip	-.04	-.34	-.17	-.11
Endurance Grip	-.29	-.30	-.20	.41
Flexed Arm Hang	-.29	-.26	-.26	-.19
Situps	-.37	-.46	-.12	-.20
Pushups	-.50	-.51	-.33	-.38
ILM Lift to 183 cm	-.14	-.27	-.18	-.32
ILM Lift to 152 cm	-.26	-.28	-.24	-.33
3. AEROBIC CAPACITY				
Step Test	-.52	.03	-.40	-.13

A3.3 Multiple Linear Regressions

The multiple linear regression models developed were based on block data rather than individual fitness measurements. These blocks comprised anthropometric, strength and endurance, aerobic capacity, lower body anaerobic and upper body anaerobic measures according to the fitness groupings in Table A8.

The results of multiple linear regression on Low High Crawl performance is indicated in Table A9a. For women less than 35 years, the introduction of strength and endurance parameters had the largest effect on the model. This was also true for young males but not for older males. Among EXPRES measurements, the variables which measure strength and endurance were combined grip and pushups. However, it must be noted also that other laboratory measures were included in this block of data.

For the Land Evacuation task the observation that strength and endurance measures most strongly influenced performance held only for males, as shown in Table A9b. No regression component had a significant effect on predicting Land Evacuation scores for women less than 35 years. For males $\geq$ 35 years, aerobic capacity was also a significant component in the regression model for the Land Evacuation task, however this was expected because these subjects were 'paced' (i.e. permitted to work at an intensity up to 90% of heart rate reserve).

For the Shipboard Evacuation Task, a similar pattern was observed in the regression models as indicated in Table A9c. For women under 35 years, anthropometric measurements, strength and endurance, and aerobic capacity measurements were significant in the regression model. For males less than 35 years, only

Table A9a.

Low High Crawl Regressed on EXPRES and Other Laboratory Tests Blocked for Fitness Type.

Block	R2 Eqn	F Eqn	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	0.126	4.03	<.01	0.126	4.03	<.01
Strength and Endurance	0.527	8.59	<.001	0.402	9.35	<.001
Aerobic Capacity	0.528	7.73	<.001	0.001	0.11	<.05
Lower Body Anaerobic	0.576	7.08	<.001	0.048	2.74	<.05
Upper Body Anaerobic	0.590	6.38	<.001	0.014	1.21	<.05
Men < 35 years						
Anthropometric	0.088	2.16	>.05	0.088	2.16	>.05
Strength and Endurance	0.331	2.97	<.01	0.243	3.11	<.01
Aerobic Capacity	0.334	2.68	<.01	.003	0.24	>.05
Lower Body Anaerobic	0.398	2.65	<.01	0.065	2.00	>.05
Upper Body Anaerobic	0.413	2.38	<.01	0.015	0.68	>.05
Men ≥ 35 years						
Anthropometric	0.027	0.34	>.05	0.027	0.34	>.05
Strength and Endurance	0.278	1.15	>.05	0.250	1.48	>.05
Aerobic Capacity	0.339	1.35	>.05	0.062	2.73	>.05

Table A9b.

Land Evacuation Task Total Time Regressed on EXPRES and Other Laboratory Tests Blocked for Fitness Type.

Block	R^2 Eqn	F Eqn	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	0.048	1.42	>.05	0.048	1.42	>.05
Strength and Endurance	0.108	0.93	>.05	0.060	0.73	>.05
Aerobic Capacity	0.112	0.87	>.05	0.004	0.36	>.05
Lower Body Anaerobic	0.147	0.90	>.05	0.035	1.00	>.05
Upper Body Anaerobic	0.211	1.18	>.05	0.064	2.87	>.05
Men < 35 years						
Anthropometric	0.086	2.10	>.05	0.086	2.10	>.05
Strength and Endurance	0.389	3.81	<.001	0.303	4.24	<.001
Aerobic Capacity	0.390	3.43	<.001	0.002	0.18	>.05
Lower Body Anaerobic	0.438	3.12	<.001	0.048	1.59	>.05
Upper Body Anaerobic	0.441	2.67	<.01	0.003	0.16	>.05
Men ≥ 35 years						
Anthropometric	0.076	1.01	>.05	0.076	1.01	>.05
Strength and Endurance	0.402	2.58	<.05	0.387	3.08	<.05
Aerobic Capacity	0.603	4.00	<.01	0.140	10.25	<.01

Table A9c.

Shipboard Evacuation Task Total Time Regressed on EXPRES and Other Laboratory Tests Blocked for Fitness Type.

Block	R^2 Eqn	F Eqn	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	0.102	3.19	<.05	0.102	3.19	<.05
Strength and Endurance	0.307	3.41	<.001	0.205	3.25	<.05
Aerobic Capacity	0.357	3.83	<.001	0.050	5.86	<.05
Lower Body Anaerobic	0.416	3.71	<.001	0.059	2.46	>.05
Upper Body Anaerobic	0.423	3.25	<.001	0.007	0.43	>.05
Men < 35 years						
Anthropometric	0.158	4.17	<.01	0.158	4.17	<.01
Strength and Endurance	0.213	1.62	<.05	0.055	0.60	>.05
Aerobic Capacity	0.213	1.45	>.05	<0.001	0.01	>.05
Lower Body Anaerobic	0.263	1.43	>.05	0.051	1.29	>.05
Upper Body Anaerobic	0.269	1.25	>.05	0.007	0.24	>.05
Men ≥ 35 years						
Anthropometric	0.068	0.90	>.05	0.068	0.90	>.05
Strength and Endurance	0.261	1.06	>.05	0.193	1.12	>.05
Aerobic Capacity	0.323	1.26	>.05	0.063	2.68	>.05

anthropometric measurements were significant; no significant variables were observed in the regression model for males over 35 years.

For the Entrenchment Dig performance scores, as shown in Table A9d, strength and endurance measures were significant for young men and women. For males over 35 years, aerobic capacity again proved significant because this was another closely 'paced', prolonged task.

In Table A10, the information combined from simple correlation measurements and multiple linear regression analysis for EXPRES scores is summarized. Here, variables of significance in either the simple correlations or multiple linear regressions are indicated. From this, it was possible to infer those variables of consequence in predicting task performance. From the totals presented for simple and block correlations, it was evident that three patterns emerged:

1. For younger subjects, correlations were dominated by the strength variables. (For the older males, as expected, VO_2 max dominated their statistical profile.)
2. For females, correlation with fitness parameters was distributed across the four EXPRES variables for Low High Crawl, Sea Evacuation and Entrenchment Dig. However, no correlations for fitness variables and Land Evacuation were apparent. This was in contrast with the male EXPRES scores which were distributed among all task performances.

A3.4 Establishment of Passing Criteria

Some difficulty existed in determining the criteria for pass

Table A9d.

Entrenchment Dig Task Total Time Regressed on EXPFES and Other Laboratory Tests Blocked for Fitness Type.

Block	R^2 Eqn	F Eqn	p	R^2 Change	F Change	p
Women < 35 years						
Anthropometric	0.042	1.22	>.05	0.042	1.22	>.05
Strength and Endurance	0.293	3.19	<.01	0.251	3.90	<.001
Aerobic Capacity	0.293	2.86	<.01	0.000	0.00	>.05
Lower Body Anaerobic	0.335	2.63	<.01	0.042	1.55	>.05
Upper Body Anaerobic	0.356	1.17	>.05	0.021	1.17	>.05
Men < 35 years						
Anthropometric	0.118	2.98	<.05	0.118	2.98	<.05
Strength and Endurance	0.357	3.33	<.01	0.239	3.19	<.01
Aerobic Capacity	0.378	3.26	<.01	0.021	1.95	>.05
Lower Body Anaerobic	0.437	3.10	<.001	0.059	1.95	>.05
Upper Body Anaerobic	0.444	2.69	<.01	0.007	0.35	>.05
Men ≥ 35 years						
Anthropometric	0.074	0.99	>.05	0.074	0.99	>.05
Strength and Endurance	0.268	1.10	>.05	0.194	1.13	>.05
Aerobic Capacity	0.391	1.69	>.05	0.123	5.88	<.05

Table A10.

Summary of reliable relationships between EXPRESS items and task variables from simple correlation and regression analyses.

EXPRES	Low-High Crawl	Land Evacuation	Sea Evacuation	Entrenchment Dig	Total c r d
Women < 35 years					
Combined Grip			c r d		1 1 1
Oxygen Consumption	c			d	1 0 1
Pushups	c			c	2 0 0
Situps	c r d			r	1 2 1
Men < 35 years					
Combined Grip		c r d	c		2 1 1
Oxygen Consumption				r	0 1 0
Pushups	c	d			1 0 0
Situps					0 0 0
Men $\geq$ 35 years					
Combined Grip	d			d	0 0 2
Oxygen Consumption	d	c		c d	1 0 2
Pushups	c	c r	c r		3 1 0
Situps	c				1 0 0

c denotes a significant simple correlation between the EXPRES measure and the task performance variable (criteria $p < .05$).

r denotes a significnat multiple regression coefficient between the block of fitness measures and the task performance variable.

d denotes ability to descriminate between passing and failing groups.

and fail for the military tasks examined in this report. Since the original protocols were defined by DPERA for the MPFS I study, these accompaning pass-fail criteria were assumed to be reasonable estimates of actual military conditions. However, in order to improve reliability and adequate measurement for the present MPFS II study, modifications were made in the task protocols. For example, the Sea Evacuation task was modified to require only one subject, not two as in the original definition; the Entrenchment Dig was changed to a "box hole" dig, and so on. As a result, the previously established time of 10 minutes for Sea Evacuation was unrealistic in the execution of the simplified task. To observe the effect of the modified protocols, cumulative frequency distribution curves for each task are presented in Figure A2.

The distribution of times for the Land Evacuation task is shown in Figure A2a. The horizontal axis represents the finishing time for 1 km. The vertical axis represents the percentage of subjects completed by that time. The two lines correspond to the two subject groups by age. Using the combined distribution, the previously established criterion of 20 minutes (as defined initially by DPERA) falls at the 25th percentile, therefore, 75% of subjects 'passed' while 25% failed. In MPFS I, using this same criterion of 20 minutes 71% of subjects 'passed' and 29% 'failed'. This suggested that a reasonable criterion for adjusting the pass level could be based on the requirement that 75% of all subjects pass the test. This definition was adopted for the other three performance tests.

By observing the cumulative distribution for the Low High

Figure A2.

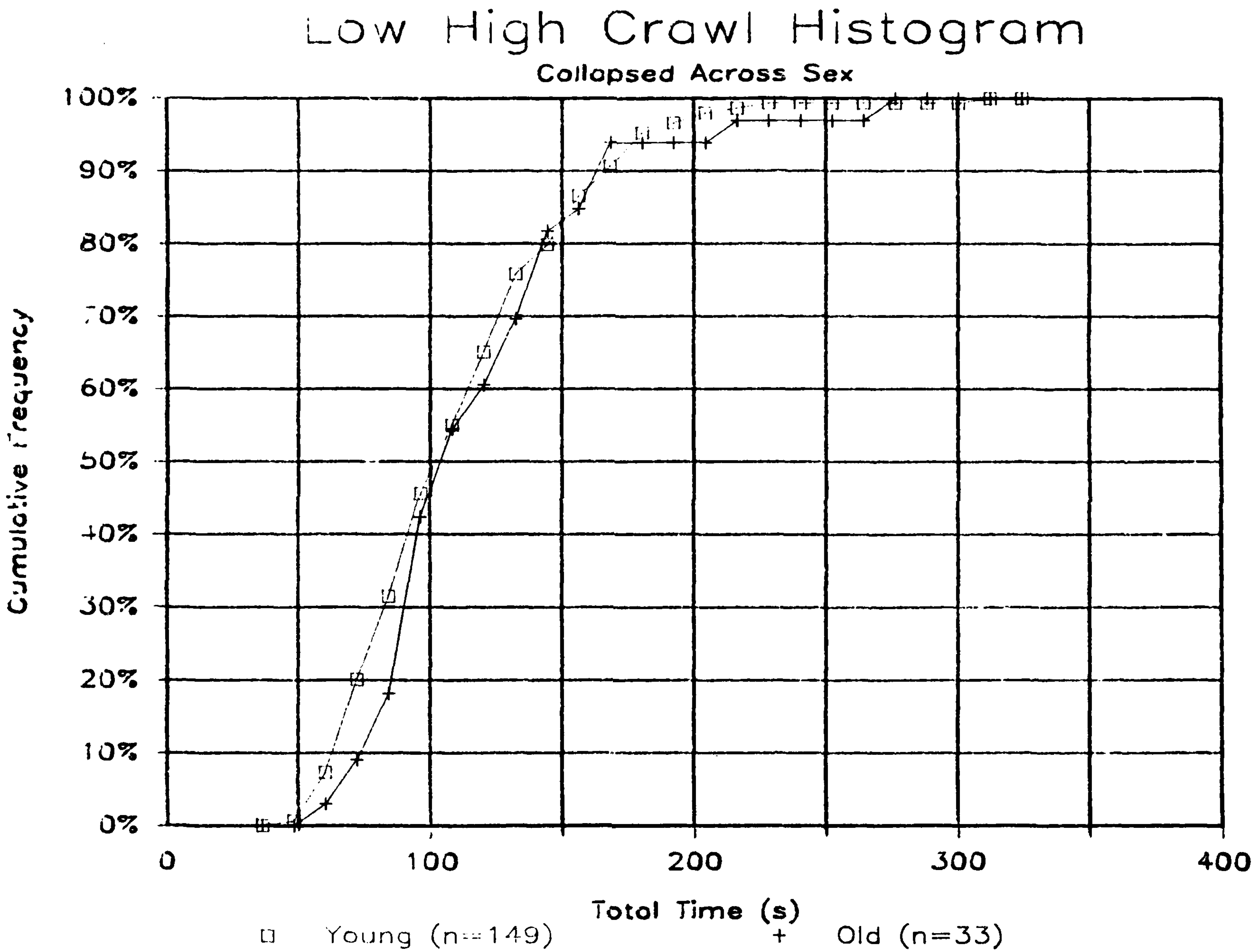
<u>Cumulative frequency graphs of young and older subjects for each task</u>.

a Low High Crawl

b Land Evacuation

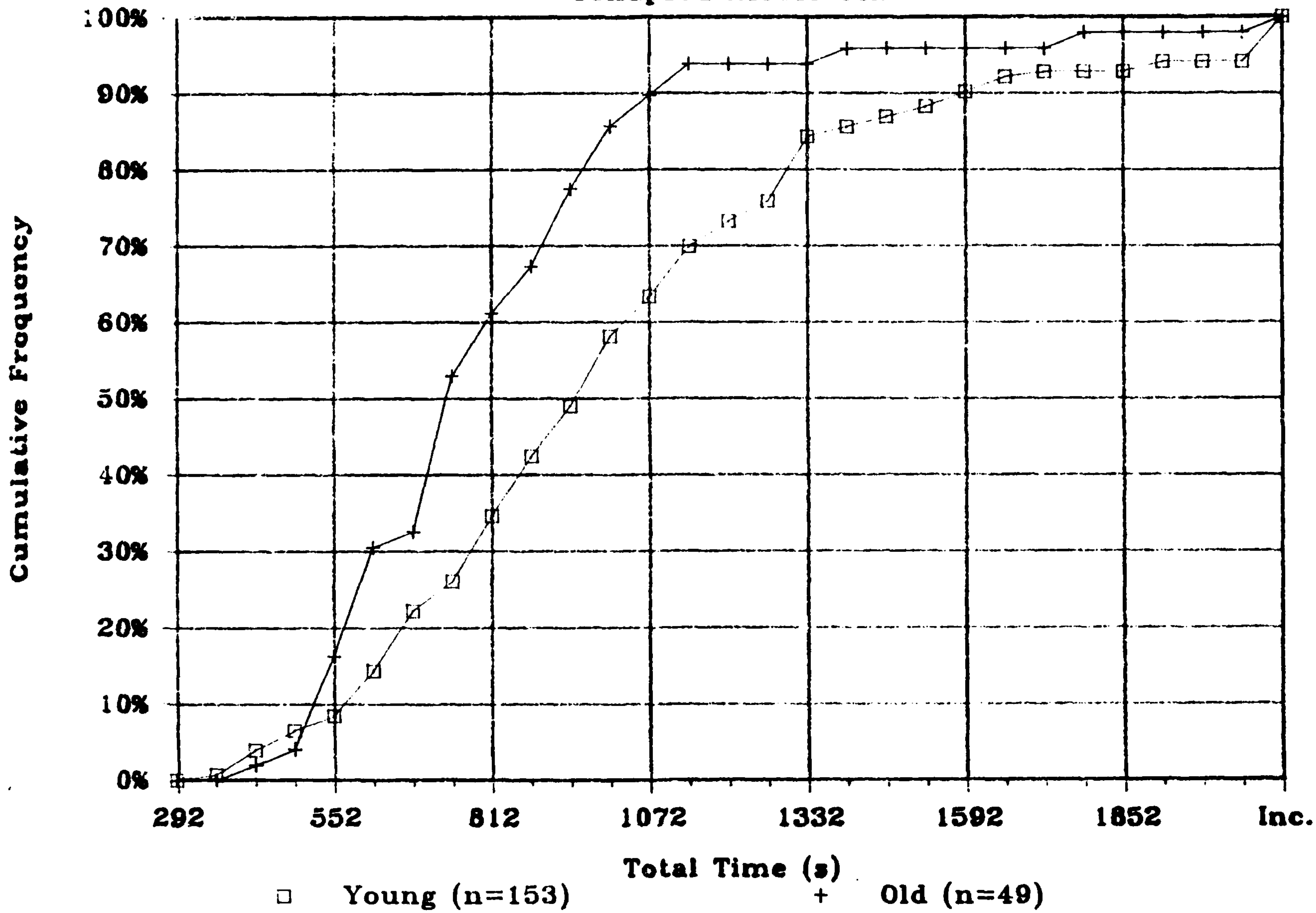
c Sea Evacuation

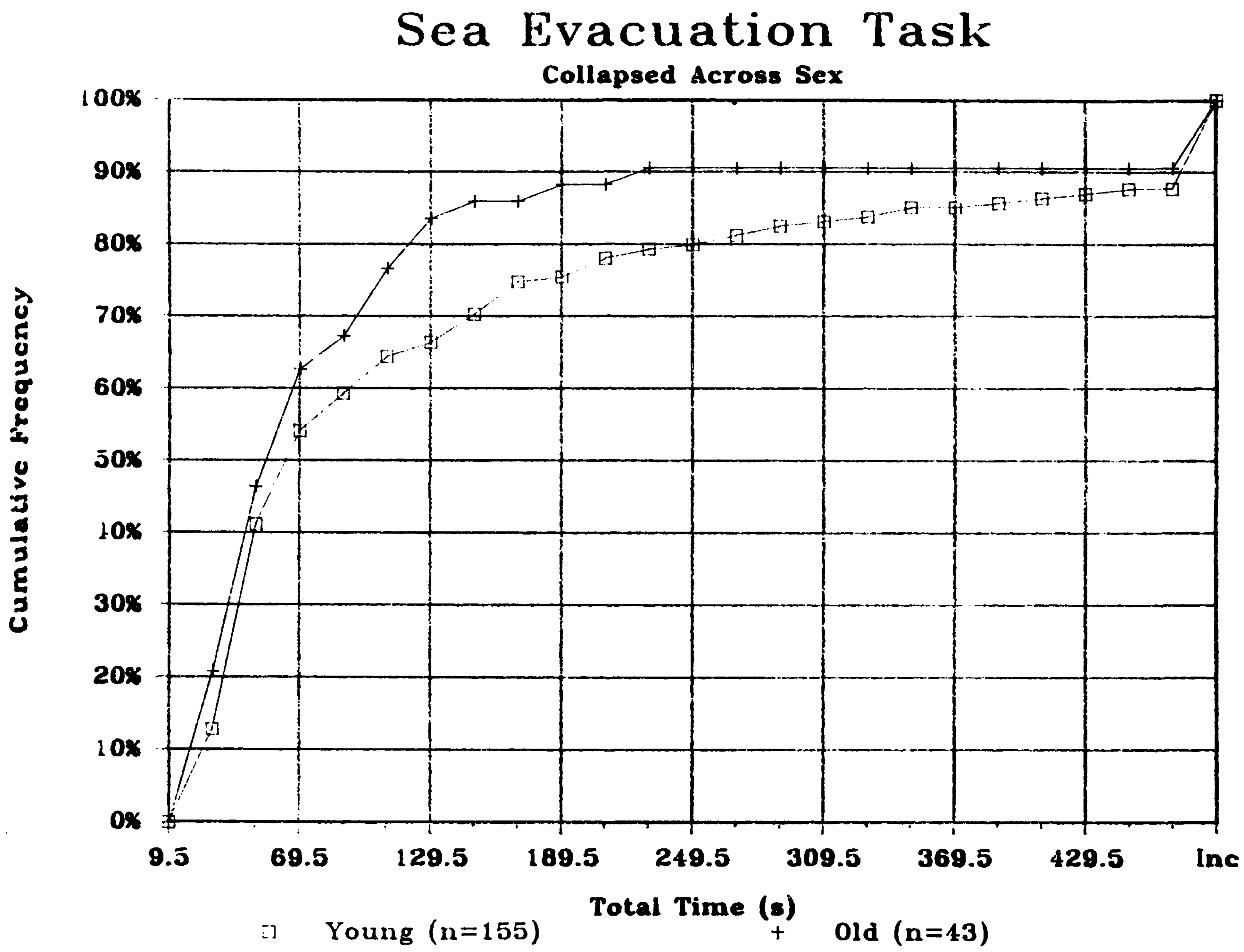
d Entrenchment Dig

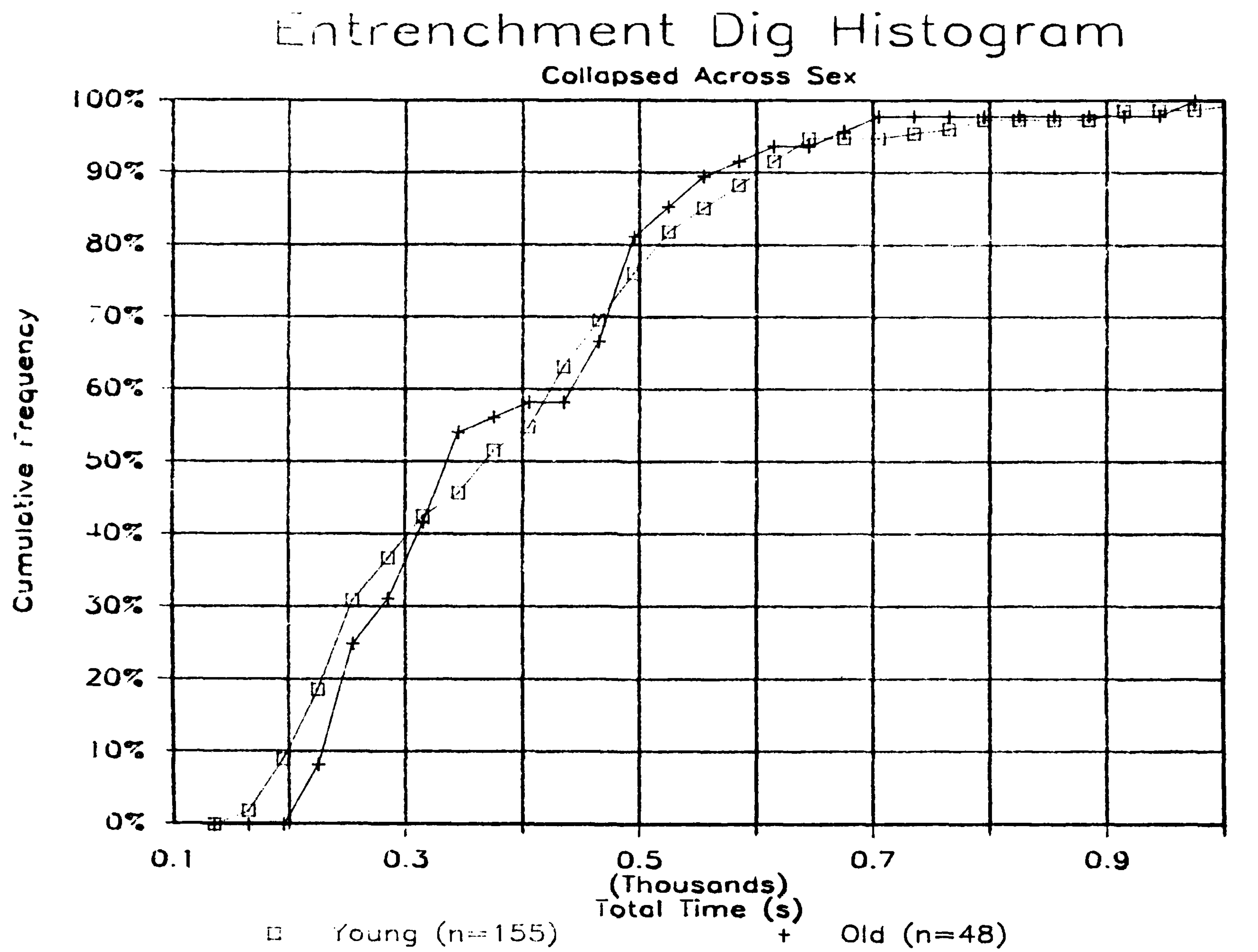

Low High Crawl Histogram
Collapsed Across Sex
Cumulative Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
Total Time (s)
Young (n=149)
Old (n=33)

Land Evacuation Task

Collapsed Across Sex




Sea Evacuation Task
Collapsed Across Sex
Cumulative Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
9.5
69.5
129.5
189.5
249.5
309.5
369.5
429.5
Inc
Total Time (s)
Young (n=155)
Old (n=43)


Entrenchment Dig Histogram
Collapsed Across Sex
Cumulative Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.1
0.3
0.5
0.7
0.9
(Thousands)
Total Time (s)
Young (n=155)
+ Old (n=48)

Crawl (Figure A2b) the 25th percentile is observed at 140 seconds. This differs from the suggested standard of 90 seconds but was deemed reasonable on the basis that the 90 second standard was the elite Marine Corps criterion set by the U.S. military.

The Entrenchment Dig scores and Sea Evacuation scores are simple adjustments for the change in test protocols. The 25th percentile for Entrenchment Dig (Figure A2d) fell at 510 seconds, (compared to 45 minutes originally established by DPERA). For the Sea Evacuation (Figure A2c), the 25th percentile was 210 seconds compared to 600 seconds in the original task definition.

A3.5 Description of Passing Groups

Having established reasonable passing criteria for the task performance, all subjects were identified as having passed or failed individual tasks. For the passers, a profile of EXPRES was established. This gave a mean and standard deviation in each of the four EXPRES variables to be expected for those subjects who were able to achieve reasonable performance on the tasks. 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 passing subjects, 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 group were tabulated.

In Table A11a, scores for the Low High Crawl are shown. For women less than 35 years, a grip score of 42.5 (kg), a VO_2 max of

Table A11a.

EXPRES Scores for the Population of Military Personnel Passing Low High Crawl Calculated Using the Normal Approximation from z-scores Based on the Sample of Passers.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
EXPRES			
Max Grip	42.5	74.4	76.5[a]
VO2 Max	31.7b	40.0	35.4[a]
Pushups	21.0[b]	12.9[b]	17.0[b]
Situps	23.9[a,b,c]	21.6	27.3[d,b]

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

31.7 (ml/kg/mm), a pushup and situp score of 21 and 23.9 respectively was required. For the latter three variables, there was a significant difference between passing and failing groups. Other significant interactions are indicated by the superscripts in the Table.

Fifth percentile for males under 35 and over 35 are also shown in Table A11a. Grip strength required was almost twice that of females. In contrast, the situp scores were approximately the same among men and women. Of note was the observation that older males required a lower VO_2 max but a higher number of pushups compared to younger males. These findings are consistent throughout the other task performances. The Entrenchment Dig is shown in Table A11b, the Land Evacuation task is shown in Table A11c, and the Sea Evacuation task in Table A11d.

It is important to note that members of each subject group passed the revised criteria. Thus, it is apparent that the three subject groups have differing fitness requirements. Such an observation was also evident from Table A10 in which different fitness variables correlated with task performance. Apparently, it was possible to perform the task in several ways. Using younger males as a reference, a high VO_2 max and high maximum grip strength was evident for most tasks. In comparison, older males required a lower VO_2 max but higher scores for pushups and situps. This suggests that the lower aerobic capacity was compensated by older men through better performance on coordinated skills such as pushups and situps. No apparent difference in strength was evident from the maximum grip scores.

Table A11b.

EXPRESS Scores for the Population of Military Personnel Passing Entrenchment Dig Calculated Using the Normal Approximation from z-scores Based on the Sample of Passers.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
Max Grip	42.8[d]	73.5	76.3[a,d]
VO2 MAX	29.7a	39.5[c]	35.3[a,b]
Pushups	19.3[b,d]	13.4	14.1[d]
Situps	18.8[c]	21.2	23.7

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 510 s.

Table A11c.

<u>EXPRESS Scores for the Population of Military Personnel Passing Land Evacuation Calculated Using the Normal Approximation from z-scores Based on the Sample of Passers.</u>

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
<u>EXPRES</u>	(46)	(66)	(40)
Max Grip	45.7[d]	76.7[a,b,c,d]	74.6[d]
VO2 Max	30.7	39.6	34.1b
Pushups	19.3	13.8[a]	12 [b,c]
Situps	20.9	21.1	24.1

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 20 min.

Table A11d.

EXPRES Scores for the Population of Military Personnel Passing Shipboard Evacuation Task Calculated Using the Normal Approximation from z-scores Based on the Sample of Passers.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
EXPRES			
Max Grip	45.0[a,b,d]	73.7[c,d]	74.4[d]
VO2 Max	30.5	39.5	35.5
Pushups	18.3	13.6	14.4[b,c]
Situps	21.4	21.1[d]	20.7[d]

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 20 min.

For females, a low VO_2 max score and lower strength (as indicated by the maximum grip score) was offset by better performance in the coordinated skills of pushups and situps. While pushups were different for males and females, situps were not. In fact, the 5th percentile for situps was higher on the Low High Crawl for females compared to younger males.

A4 IMPLICATIONS

A4.1 Summary of Standards

No standard can be used to describe the fitness of those subjects able to pass performance standards for the tasks examined in this study which does not account for gender and age. As a result, three sets of standards are proposed. These are shown in Table A12.

Consider the combined Grip score for women $\leq$ 35 years. From Table A10, the Sea Evacuation and Entrenchment Dig task had the most significant correlations with the grip strength parameter. Observing Table A11b shows a grip score of 42.8 for the Entrenchment Dig. Table A11a shows a grip strength of 45.0 for the Sea Evacuation. The higher of these is required as the minimum fitness standard (i.e., 45 kg). By a similar process, each fitness standard was established.

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

1. Biomechanically, it was ovserved that tasks are performed by the different groups in different manners.
2. Men $\geq$ 35 years were limited by performing at 90% of their maximal capacity.
3. Strength differences between men and women are well known. The difference in grip scores between men and women seems offset at least for younger women by the increased performance in the coordinated skills of

Table A12.

Minimum Physical Fitness Standard Based on a representative sample of CF Personnel.

Sub Groups	Combined Grip (kg)	Oxygen Consumption ml/kg/min	Pushups (Number)	Situps (Number)
Women < 35 years	45	30	21	24
Men < 35 years	77	40	13	21
Men ≥ 35 years	77	35	14	27

situps and pushups.

4. The lower VO_2 max (i.e., 32 ml/kg/min) of females was not a limiting factor in their ability to perform tasks. For younger males, however, VO_2 max below 40 ml/kg/mm limited performance.

5. A final argument for separate standards is on a technical basis only. Namely, female pushups differ in technique from those for males, thus, it is impossible to compare this EXPRES parameter across gender in any case.

A4.2 Prediction of Passing and Failing

It is important to note that the empirical model was developed one task at a time; no consideration was given to the ability of an individual to pass all tasks. To examine this likelihood, the performance criteria established for each group was used to divide the populations into passing and failing groups on the basis of 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. The results for this analysis are shown in Table A13.

For younger males (Table A13a), of those predicted to pass all tasks on the basis of fitness 94% were able to do so. However, of those predicted to fail only 18% actually failed one or more of the tests. The opposite situation arose for young females (Table A13b). Of those predicted to pass on the basis of fitness, 64% actually failed. However of those predicted to fail, 90% actually did fail. For older men (Table A13c), of those predicted to pass 81% actually passed all tasks. The prediction of failing was 100% accurate in this case. Combining

Table A13a.

Impact of Minimum Physical Fitness Standards: An examination of EXPRES Standards Applied to Males ≤ 35 Years Across all Tasks.

Condition	Actual Performance n	Predicted Correctly Classified n	Performance Incorrectly Classified n
Passed (all tests)	56	47 (true positives)	9* (false negative)
Failed (one or more tests)	5	2 (true negatives)	3 (false positive)
Total	61	49	12

*The incidence of subjects predicted to fail but actually passed all tasks was 14.8% of the total sample.

Table A13b.

Impact of Minimum Physical Fitness Standards: An Examination of EXPRES Standards Applied to Females ≤ 35 Years Across all Tasks.

Condition	Actual Performance n	Predicted Correctly Classified n	Performance Incorrectly Classified n
Passed (all tests)	22	20 (true positives)	2* (false negative)
Failed (one or more tests)	53	17 (true negatives)	36 (false positive)
Total	75	37	38

*The incidence of subjects predicted to fail but actually passed all tasks was 2.7% of the total sample.

Table A13c.

Impact of Minimum Physical Fitness Standards: An Examination of EXPRES Standards Applied to Men Over 35 Years Across all Tasks.

Condition	Actual Performance n	Predicted Correctly Classified n	Performance Incorrectly Classified n
Passed (all tests)	21	21 (true positives)	0* (false negative)
Failed (one or more tests)	9	4 (true negatives)	5 (false positive)
Total	30	25	5

*The incidence of subjects predicted to fail but actually passed all tasks was 0% of the total sample.

all of the data as indicated in Table A13d gives a reasonable overall picture of the ability of these criteria to predict performance. Clearly the method is generous, being based on a fixed incidence rate of false negatives. False negatives are those subjects predicted to fail on the basis of fitness but who actually passed all tasks. This is 6.6% in the total sample population. By necessity this is offset by a high false positive rate. The false positive rate comprises those subjects predicted to pass but who actually failed one or more tasks. This rate is 26%.

It is possible to adjust these levels of predictability if all tasks are not required to be performed at the pass level. For example passing three or more performance tests may be a better indicator then having to pass all tasks.

A4.3 Comparison of Proposed Standards to Military and Canadian Population

In order to judge whether the proposed standards are reasonable, the values for EXPRES scores are compared to normative data for the Canadian and Military populations as shown in Table A14. In general, all of the fitness criteria exceed the 5th percentile for both populations. In some instances criteria exceed the 50th percentile for both Military and Canadian samples. The implications of such a standard is to ensure that the minimum fitness level is above the minimum fitness level expected in the population. It is important that, overall, such levels do not exceed the 50th percentile since such a level would seem too rigorous for a 'minimum' standard.

Table A13d.

Impact of Minimum Physical Fitness Standards: An Examination of EXPRES Standards Across all Groups.

Condition	Actual Performance n	Predicted Correctly Classified n	Performance Incorrectly Classified n
Passed (all tests)	99	88 (true positives)	11* (false negative)
Failed (one or more tests)	67	23 (true negatives)	44 (false positive)
Total	166	111	55

*The incidence of subjects predicted to fail but actually passed all tasks was 6.6% of the total sample.

Table A14.

Examination of the Minimum Physical Fitness Standard MPFS in comparison to military and Canadian population normative standards.

Normative Standard	Age Range	Combined Grip	Oxygen Consumption	Pushups	Situps
Women < 35 years					
Proposed MPFS		(45)	(32)	(21)	(24)
Military[a] Rank (%ile)	20-29	<5	5	20	15
	30-39	<5	25	35	35
Canadian[b] Rank (%ile)	20-29	25	10	65	40
	30-39	20	35	70	70
Men < 35 years					
Proposed MPFS		(77)	(40)	(14)	(21)
Military[a] Rank (%ile)	20-29	5	5	5	5
	30-39	5	20	10	10
Canadian[b] Rank (%ile)	20-29	10	5	20	5
	30-39	10	25	30	15
Men ≥ 35 years					
Proposed MPFS		(77)	(35)	(14)	(24)
Military[a] Rank (%ile)	30-39	5	5	10	20
	40-49	5	15	15	40
Canadian[b] Rank (%ile)	30-39	10	5	30	25
	40-49	15	20	40	45

Note. Ranks represented in the table have been rounded to the nearest 5th percentile.

a (Jette, 1985)

b (Reid & Thomson, 1985)

A4.4 Additional Standards Based on the Incremental Lifting Machine

In addition to EXPRES texts, the incremental lifting machine (ILM) has been under consideration as a task-specific measure of fitness. Results from previous contracts in MPFS I and OPSS (the CF Occupational Physical Selection Standards) have not generally indicated a strong correlation between various task scores and ILM scores. In the present study, MPFS II, all subjects performed an ILM lift to 152 cm and 183 cm, according to a standardized protocol. The data obtained (ILM scores) were maximal lift masses at each height.

The correlation between ILM scores and task performance for each of the four specific tasks analyzed in Section A is shown in Table A15a. Significant simple correlations are indicated by asterisks. If an ILM score was also a significant contribution to a multiple linear regression model, the significance is also indicated (r). In all cases, negative correlations exist since a greater mass lifted corresponded to a lower task performance time.

For women < 35 years, the 152 cm lift indicated a significant correlation with Sea Evacuation and Entrenchment Dig performance. For men < 35 years, the 183 cm lift correlated weakly with their Sea Evacuation, while the 152 cm lift correlated significantly with Entrenchment Dig performance. For men ≥ 35 years, no significant correlations were observed. The highest correlation coefficient was obtained between the 152 cm lift and Sea Evacuation performance.

Based on the 75% sample criterion discussed in Section A3.4,

Table A15a.

Summary of Relationships Between ILM Scores and Task Performance from Simple Correlation and Regression Analyses.

	Low-high Crawl	Land Evacuation	Sea Evacuation	Entrenchment Dig
Women < 35 years				
Lift to 183 cm	-0.21	-0.25	-0.24	-0.28
Lift to 152 cm	-0.26	-0.30	-0.27 (r)	-0.37* (r)
Men < 35 years				
Lift to 183 cm	-0.23	-0.32	-0.15 (r)	-0.33
Lift to 152 cm	-0.21	-0.35	-0.13	-0.39**
Men ≥ 35 yrs				
Lift to 183 cm	-0.27	-0.14	-0.32	-0.18
Lift to 152 cm	-0.27	-0.26	-0.33	-0.24

* $p < .05$
** $p < .001$
(r) indicates a significant variable in a multiple regression model.

ILM scores for the passing group of each task were analysed. The fifth percentile ILM scores for these passing groups are shown in Table A15b. Note that these data are insensitive to differences between tasks.

To select appropriate values for ILM fitness standards, the highest correlated tasks for Table A15b were used. In all cases, an ILM 152 cm test resulted, giving a required score of 18.2 kg for women $<$ 35 years, 34.4 kg for men $<$ 35 years and 33.6 kg for men $\geq$ 35 years. Unfortunately, the resolution of mass on the ILM does not allow implementation of these calculated standards, since 2.5 kg and 5 kg increments are provided for females and males respectively. To examine the implication of this feature, various 'standards' are presented in Table A15c. As well, percentile scores are indicated for the passing population for each of the "standards". The ILM score closest to the fifth percentile is indicated for each group by an asterisk. In all cases this distorts the basic premise of the MPFS standards presented, and for this reason the implementation of an ILM score in the MPFS is not recommended at this time.

Table A15b.

Incremental Lifting Machine (ILM) Fifth Percentile Scores for Personnel Passing Task Performance Criteria (kg).

	Low-high Crawl	Land Evacuation	Sea Evacuation	Entrenchment Dig
Women < 35 years				
Lift to 183 cm	15.1	15.0	16.2	14.7
Lift to 152 cm	18.6	18.8	19.1	18.2
Men < 35 years				
Lift to 183 cm	31.9	31.7	31.5	31.6
Lift to 152 cm	35.2	34.6	34.3	34.4
Men ≥ 35 years				
Lift to 183 cm	27.8	28.7	27.8	28.0
Lift to 152 cm	33.0	34.2	33.6	34.1

Table A15c.

Suggested ILM Fitness Standards by Subject Group and Percentile Scores of Subjects in a Specific Group Passing Each Standard.

	152 cm ILM Score (kg)	Percentile of Passing Group (%ile)
Women < 35 years	17.5*	3.9
	(18.2)	(5th)
	20.0	8.9
Men < 35 years	30.0	1.9
	(34.4)	(5th)
	35.0*	5.7
Men ≥ 35 years	30.0	2.2
	(33.6)	(5th)
	35.0*	6.8

MPFS values determined for the ILM lift to 152 cm, established at the 5th percentile for subjects that 'passed' in the various groups; however, because of the ILM's mass increments, these calculated values can not be produced using the existing ILM protocol.

* Scores closest to 5th percentile.

A5 CONCLUSIONS AND RECOMMENDATIONS

A5.1 Task Definitions and Performance Criteria

The 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 is stable and is based on realistic task requirements.

WE THEREFORE RECOMMEND THAT:

The Canadian Armed Forces continue to use operational task definitions rather than actual task definitions, that these definitions for the common Military tasks continue to be refined, and that the 75th percentile continue to be used as the passing criteria to evaluate performance. Since the present protocols and standards are relative to the current population sampled, these task criteria will be upgraded as CF personnel improve their fitness performance.

A5.2 Fitness Content in the Common Military Tasks

Not less than 10% nor greater than 56% of task performance can be explained by measures of physical fitness or capacity. Furthermore, it was evident that EXPRES variables which related to task performance differed among the three groups studied, (men under 35 years, men over 35 years, women under 35 years of age) despite the fact that task performance requirements were identical for all three groups.

WE THEREFORE RECOMMEND THAT:

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

A5.3 Minimum Physical Fitness Standards for Men Under 35 Years

The EXPRES scores listed in Table A12 reasonably represent the 5th percentile of the male population under 35 years of age able to pass the performance criteria established for the seven common tasks.

WE THEREFORE RECOMMEND THAT:

Minimum Fitness Standards be established fcr men under 35 years of age based on the validation study of two sample populations observed in MPFS I and MPFS II. We further recommend that as CF personnel fitness levels improve, future studies be undertaken to upgrade the task performance criteria.

A5.4 Minimum Physical Fitness Standards for Women Under 35 Years

The EXPRES scores listed in Table A12 reasonably represent the 5th percentile of the female population under 35 years of age able to pass the performance criteria established for the seven common tasks.

WE THEREFORE RECOMMEND THAT:

A Minimum Fitness Standard for younger women be established based on Table A12 pending appropriate validation studies.

A5.5 Safety Restrictions With Older Subjects

Compliant with the American College of Sports Medicine Guidelines, no CF personnel over thirty-five years of age was permitted to execute tasks at maximal heart rate. This safety restriction somewhat modified the MPFS standards determined for these subjects. However, the EXPRESS scores listed in Table A12 reasonably represent the 5th percentile of the male population over 35 years of age able to pass the performance criteria established for the common military tasks.

WE THEREFORE RECOMMEND THAT:

A Minimum Fitness Standard for older men be established based on Table A12 pending appropriate validation studies; that the safety restriction imposed in this study be continued for routine MPFS testing with subjects $\geq$ 35 years; amd that an independant pilot study be undertaken, employing volunteer subjects permitted to work at maximal intensity, to identify the impact that this restriction has on both task performance and MPFS values for this group.

A5.6 Minimum Physical Fitness Standards For Women Over 35 Years

There were too few females population over 35 years of age studied to develop a minimum fitness standard.

WE THEREFORE RECOMMEND THAT:

A representative sample population of women over 35 years be studied to develop a minimum fitness standard.

A5.7 Multifactorial Nature of Task Performance

Selected psychological factors assessed on two tasks explained 4% to 10% of the variance of task performance. Technique, cognitive skills, experience and peer cohesion were noted as contributing factors to task performance.

WE THEREFORE RECOMMEND THAT:

The common military tasks be reviewed in terms of global objectives for these tasks; it is intended that techniques by which a global objective is attained be analysed in terms of specific tasks, equipment design and other ergonomic factors which may optimize the performance of CF personnel.

A5.8 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 once Minimum Physical Fitness Standards have been validated for all CF personnel, 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

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DETAILED EXPERIMENTAL REPORTS

In section B, seven separate reports are presented detailing subjects' results on the individual tests and tasks. These findings formed the basis for the data analyses and conclusions presented in Section A; the individual results, by subject, upon which the detailed reports (i.e., Sections B1 through B7) were based, are tabulated in Appendix E. Section B1 summarizes the participants non-military testing data, their physical fitness determined according to EXPRES as well as additional fitness tests and strength measures determined according to the ILM protocol. Sections B2 through B7 summarize subjects' results on the individual military tasks: the low-high crawl in B2; two stretcher evacuation tasks, overland and shipboard, in Sections B3 and B4 (respectively); two repetitive submaximal lifting tasks - the entrenchment dig and sand bag carry - in B5 and B6; and a psychological profile of subjects before and after performing certain of the above tasks in Section B7.

After consultation with DCIEM and ranking Officer Personnel in the Canadian Forces, for the present MPFS II study several of the common military tasks as initially defined by the CF were modified in an effort to produce more 'pure tests; the rationale for each modification is discussed in the introductions to each section. As well, additional data analyses were incorporated into these task modifications; where appropriate, task performance was analyzed incrementally and drop-off indices were calculated (see Appendix A, MPFS II Contract proposal: Secondary Objectives Section). These analyses attempted to reduce the number of extraneous factors which confounded the data analyses in MPFS I (see Final Report: Section A). Summary of pilot testing (conducted in the Spring of 1986) in which test-retest reliability of these protocol modifications was assessed, are presented in Appendix D.

SECTION B1

ANTHROPOMETRIC, EXPRES and LABORATORY DATA ANALYSES

SECTION B1

ANTHROPOMETRIC, EXPRES and LABORATORY DATA ANALYSES

B1.1 Introduction

This section describes the military personnel according to EXPRES, the CF anthropometric and titness test battery, and selected laboratory fitness tests. EXPRES measures included muscular endurance (Pushups and Situps), aerobic endurance (a predictive submaximal Step Test), muscular strength (Combined Hand Grip), and anthropometric data (height, weight, selected girth measurements and percent body fat); however, the latter, body fat and girth measurements, were not obtained in the present study because each was shown to correlate poorly with performance measures (Stevenson *et al*., 1985). Laboratory tests included Hand Grip Endurance, the Wingate Tests of both lower- and upper-body anaerobic power, an additional measure of upper body endurance (the Flexed Arm Hang) and maximal Incremental Lifting Machine (ILM) lifts to 150 cm and 183 cm. The purpose of this test battery was to profile each subject according to fitness in order that these data might be used in developing the minimum physical fitness levels required for satisfactory performance of the military tasks (Section B2-B6).

B1.2 Subjects

A total of 208 CF personnel participated in MPFS II. The 85 personnel tested at CFB Ottawa were obtained using a stratified sampling procedure; it was intended that those tested include equal numbers of subjects who had, on previous EXPRES testing, exhibited VO_2 max scores above and below the 50th percentile for the military population for each gender and by age group (i.e., above and below 35 years). This procedure was reasonably successful for the < 35 year groups, but less so for the older groups. Only eight women and 41 men were included in these latter groups, thus data for the group of older women is presented throughout Section B in descriptive terms only.

On the other hand, the 74 participants from CFB Borden were Personnel Awaiting Training (PATs). Since these personnel had not yet undergone EXPRES testing, it was not possible to use a stratified sampling procedure. Thus, all PATs who were on-site for the testing week were asked to participate.

Anthropometric data for these groups of subjects are presented in Table B1.1. As expected, the personnal tested at CFB Borden were significantly younger ($\underline{M}$=20.9, SD=2.4) than their more veteran counterparts in the < 35 year group in Ottawa ($\underline{M}$=27.0, SD=4.2; $t(149)=-10.5$, $p<.001$). On the other hand, within gender comparisons of height and weight indicated no significant difference between the two subgroups.

B1.3 Procedure

In the present study every consideration was given to subject safety and comfort, particularly considering the rigorous physical nature of both the fitness tests and military tasks. Of special concern in MPFS II was the large number of subjects 35 years and older (see Appendix B, documentation related to Ethics Reviews). The American College of Sports Medicine Guidelines (1985; p. 39-41) clearly state that persons $\geq$ 35 years of age

Table B1.1

Summary of Physical Characteristics of the Sample by Testing Site, Age Group and Sex.

		Age (yr)	Height (cm)	Weight (kg)
Men < 35 years				
CFB Borden (n=50)	M	20.4	177.2	74.4
	SD	2.0	6.9	10.3
	(min-max)	(17-25)	(164-195)	(56-105)
CFB Ottawa (n=21)	M	31.3	176.2	82.0
	SD	2.5	5.0	11.1
	(min-max)	(22-34)	(167-184)	(62-106)
Combined (n=71)	M	23.9	176.9	76.6
	SD	5.6	6.3	11.0
	(min-max)	(17-34)	(164-195)	(56-106)
Men ≥ 35 years[1] (n=41)	M	39.9	175.9	81.2
	SD	3.9	6.2	10.0
	(min-max)	(35-47)	(164-193)	(61-103)
Women < 35 years				
CFB Borden (n=24)	M	21.9	165.7	61.4
	SD	2.8	6.5	8.3
	(min-max)	(18-27)	(152-175)	(47-88)
CFB Ottawa (n=64)	M	25.6	163.6	62.4
	SD	3.7	6.0	9.4
	(min-max)	(20-34)	(152-178)	(44-87)
Combined (n=88)	M	24.7	164.1	62.1
	SD	3.8	6.2	9.1
	(min-max)	(18-34)	(152-178)	(44-88)
Women ≥ 35 years[1] (n=8)	M	36.5	166.0	61.7
	SD	1.1	6.7	10.8
	(min-max)	(35-38)	(156-174)	(44-80)

[1] Participants ≥ 35 years of age were tested at CFB Ottawa only.

should not sustain an exercise intensity in excess of 90% of their maximal capacity. As a consequence, in the present study, in the interests of safety these subjects wore heart rate monitors throughout testing in order to monitor their on-going heart rate changes. Ninety percent capacity was determined by heart rate response as predicted by the following equations, according to the exact age and gender of the subject, and this value was preprogrammed into each heart rate monitor:

Men 90% Heart Rate = 0.9([220-Age]-70) + 70 bpm

Women 90% Heart Rate = 0.9([210-Age]-70) + 70 bpm;

where 70 bpm is assumed to be the resting heart rate.

When subjects $\geq$ 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 below 90%; in some instances, they were not permitted even to attempt an activity (see Table B1.2). In any case, these subjects were not given the freedom to complete the tests and tasks as vigorously as the younger subjects, often having to pace themselves throughout longer task performances. Therefore, data for older subjects were analyzed separately from the younger groups and the findings interpreted in this light. Throughout Section B, specific instances are highlighted and discussed accordingly.

Detailed methodologies of the test batteries are presented in Appendix C, therefore, throughout Section B testing protocols for the various data measurements are summarized only. EXPRES testing was conducted by qualified personnel, CF Physical Education and Recreation Instructors (PERI), but not at the time

Table B1.2

Summary of EXPRES Scores by Testing Site, Age Group and Sex.

		Pushup	Situp	Combined Grip		Predicted
		(no)	(no)	(kg)	(kg/kg)	$VO2_{MAX}$
Men < 35 years						
CFB Borden	M	30.1	37.1	97.8	1.3	49.8
(n=50)	SD	9.3	9.3	16.2	0.24	4.2
	(min-max)	(9-59)	(21-71)	(53-132)	(0.8-2)	(42-58)
CFB Ottawa	M	29.9	35.7	105.8	1.3	44.4
(n=21)	SD	11.5	9.2	13.9	0.22	5.4
	(min-max)	(10-58)	(22-60)	(79-137)	(1.0-1.8)	(37-56)
Combined	M	30.0	36.7	100.1	1.3	48.2
(n=71)	SD	9.9	9.2	15.9	0.23	5.2
	(min-max)	(9-59)	(21-71)	(53-137)	(1.8-2.0)	(37-58)
Men > 35 years[1]						
(n=41)						
	M	30.7	37.0	106.6	1.3	41.7
	SD	11.0	7.8	19.4	0.26	4.6
	(min-max)	(7-60)	(20-52)	(66-145)	(0.9-2.1)	(32-56)
Women < 35 years						
CFB Borden	M	35.0	35.3	59.7	1.0	38.0
(n=24)	SD	10.3	7.8	12.8	0.21	2.9
	(min-max)	(19-61)	(25-51)	(31-89)	(0.4-1.3)	(31-42)
CFB Ottawa	M	33.3	34.8	58.6	1.0	36.8
(n=64)	SD	10.3	11.2	9.6	0.20	4.7
	(min-max)	(10-56)	(11-70)	(39-86)	(0.6-1.5)	(23-56)
Combined	M	33.8	35.0	59.0	1.0	37.1
(n=88)	SD	10.3	10.4	10.6	0.20	4.3
	(min-max)	(10-61)	(11-70)	(31-89)	(0.4-1.5)	(23-56)
Women > 35 years[1]						
(n=8)						
	M	28.6	31.8	74.1	1.2	35.6
	SD	11.7	6.1	41.4	0.6	3.4
	(min-max)	(15-45)	(24-41)	(37-170)	(0.8-2.6)	(31-41)

[1] Participants $\geq$ 35 years of age were tested at CFB Ottawa only.

of mass testing of the performance tasks. On the other hand, the laboratory tests were completed on site at CFB Ottawa and Borden during the June, 1986 testing sessions.

Physical Characteristics of Subjects. Standing height and body mass were determined by means of a Delto scale and adjustable height armature.

EXPRES Fitness Battery. EXPRES is the standardized CF test of physical fitness with normative data available for Canada's military population, adjusted for age and gender (readers are referred to the EXPRES Handbook). The following four test items were recorded by PERI and forwarded to Queen's Ergonomics Research Laboratory: i) Pushups, the maximal number performed (note, women performed modified pushups from the knees - see EXPRES Handbook); ii) Situps, the number completed in one minute; iii) Combined (right and left hand) Maximal Grip score, measured by hand grip dynamometry; iv) predicted maximal oxygen connsumption, determined by the Fitness Canada Step-Test protocol.

Laboratory Test Battery. The laboratory fitness tests were completed in gymnasia at CFB Borden and Ottawa. Subjects were instructed to complete a general cardiovascular warm-up prior to commencing this test battery. The test were performed in random order with at least thirty minutes between each of the anaerobic power tests. The following five items were included in the battery:

Wingate Upper-Body Power Test: 30 second supra-maximal arm ergometer test for determining upper-body and arm power;

Wingate Lower-Body Power Test: 30 second, supramaximal leg ergometer test for determining lower-body, leg power.

Flexed Arm Hang: using a small ladder for assistance, subjects grasped a horizontal bar so that the eyes were level with the bar. With the ladder removed, subjects remained suspended in this position (i.e., eyes at bar level) for as long as possible; by stopwatch, time was recorded to the nearest second.

Endurance Hand Grip: squeezing the hand dynamometer initially to 20 kg, subjects held this force for as long as possible. By microcomputer, time was recorded to the nearest 10th second. Both the dominant and non-dominant hands were assessed.

ILM Maximal Lifts: maximal mass lifted from floor to heights of a) 183 cm, and b) 150 cm, employing correct ILM lifting protocol (i.e., maintenance of positive velocity throughout the lift).

B1.4 Results and Discussion

The summary scores for the EXPRES variables are presented in B1.2. Although the mean scores for young men and women in the Borden group tended to be higher than those in the Ottawa group, this difference reached significance only for the predicted VO_2max of young men ($t(65)=4.41$, $p<.001$). Within each gender, no significant differences were observed on the EXPRES items, with one exception. The younger males recorded significantly higher VO_2 max values than males $\geq$ 35 years ($t(106)=6.55$, $p>.001$).

Comparisons by gender highlighted interesting differences in the EXPRES results. The maximum number of pushups and situps for both men and women were almost identical, however the specific pushup exercise performed by each group was different (see protocols). The largest discrepancy between genders was noted on combined grip scores, and this was also the case comparing the younger and older subject groups.

In table B1.3, laboratory test results are tabulated and, again, the same comparisons (as above) seemed warranted. However, it should be noted that subjects $\geq$ 35 did not perform the anaerobic ergometer tests (see footnotes below tables). First, on the flexed arm hang and maximal ILM lifts, men $<$ 35 years were significantly better than the older group ($t(107)=7.486$, $p<.001$; $t(108)=4.351$, $p<.001$, respectively), however there was no age effect observed for women. The endurance grip times of the $\geq$ groups (both men and women) were sustained, on average, well over a minute longer than by those under 35 years. Contrasting male and female personnel on all laboratory tests (including the ergometer tests performed by the younger groups), scores for men were consistently greater. Nevertheless, considerable overlap was recorded between the higher female scores and the male personnel. The personnel at Borden (both men and women) performed significantly better than their Ottawa counterparts on the flexed arm hang ($t(66)=6.82$, $p<.001$; $t(80)=6.68$, $p<.001$, for men and women respectively) and on the ILM max lift to 183 cm ($t(67)=4.002$, $p<.001$; $t(81)=7.040$, $p<.001$ respectively). However, Ottawa personnel performed significantly better on the endurance grip test than those from Borden ($t(63)=-7.23$, $p<.001$; $t(74)=7.39$, $p<.001$ for men and women respectively).

A conscious objective of MPFS II was to enlist CF personnel

Table B1.3

Summary of Laboratory Test Scores for the CF Personnel by Testing Site, Age Group and Sex.

		Flexed Arm Hang (s)	Combined Endurance Grip (s)	ILM Max. Lift to 183 cm (kg)	ILM Max. Lift to 150 cm (kg)
Men < 35 years					
CFB Borden	M	45.3	156.4	46.4	50.9
(n=50)	SD	15.4	83.1	9.2	9.2
	(min-max)	(15-86)	(44-374)	(25-70)	(25-70)
CFB Ottawa	M	37.2	201.4	45.7	51.4
(n=21)	SD	20.9	85.3	8.8	10.7
	(min-max)	(5-100)	(77-437)	(35-70)	(30-75)
Combined	M	42.9	169.5	46.1	51.1
(n=71)	SD	17.4	85.6	9.0	10.2
	(min-max)	(5-100)	(44-437)	(30-70)	(25-75)
Men ≥ 35 years[1]	M	38.2	265.8	44.2	48.8
(n=41)	SD	13.5	110.9	9.5	8.9
	(min-max)	(12-67)	(93-577)	(20-65)	(22.5-65)
Women < 35 years					
CFB Borden	M	19.9	57.9	25.8	28.1
(n=24)	SD	14.7	42.2	5.4	6.3
	(min-max)	(1-61)	(10-173)	(17.5-37.5)	(20-40)
CFB Ottawa	M	14.4	76.5	23.0	26.4
(n=64)	SD	12.7	39.6	6.1	5.9
	(min-max)	(0-63)	(3-210)	(12.5-45)	(20-45)
Combined	M	15.8	70.8	23.7	26.9
(n=88)	SD	13.4	41.0	6.0	6.0
	(min-max)	(0-63)	(3-210)	(12.5-45)	(20-45)
Women ≥ 35 years[1]	M	21.7	147.6	22.2	24.7
(n=8)	SD	14.8	82.5	3.9	3.9
	(min-max)	(5-48)	(33-231)	(17.5-27.5)	(20-32.5)

[1] Participants ≥ 35 years of age were tested at CFB Ottawa only.

Table B1.3(cont)

	Arm Ergometer			Leg Ergometer		
	Total Work (kj)	Peak Power (w)	Drop-off (%)	Total Work (kj)	Peak Power (w)	Drop-off (%)
Men < 35 years						
CFB Borden (n=50)						
M	8.0	266.4	44.9	17.2	730.5	43.1
SD	1.8	59.3	7.6	2.6	125.2	8.5
(min-max)	(6-18)	(195-599)	(29-63)	(12-23)	(498-1055)	(25-57)
CFB Ottawa (n=21)						
M	7.4	247.3	49.2	17.3	724.5	40.7
SD	0.7	24.4	11.4	1.7	102.7	9.7
(min-max)	(5-8)	(178-283)	(29-65)	(14-20)	(565-961)	(25-57)
Combined (n=71)						
M	7.8	261.1	46.1	17.2	728.9	42.4
SD	1.6	52.6	8.9	2.3	118.8	8.8
(min-max)	(5-18)	(178-599)	(29-65)	(12-23)	(498-1055)	(25-57)
Women < 35 years						
CFB Borden (n=24)						
M	3.7	125.0	44.8	11.2	472.8	39.1
SD	0.5	16.2	7.3	1.7	72.5	9.3
(min-max)	(3-5)	(96-152)	(27-56)	(8-14)	(313-634)	(20-55)
CFB Ottawa (n=64)						
M	3.6	121.3	44.1	11.6	493.2	41.3
SD	0.8	26.7	10.6	2.0	87.7	9.5
(min-max)	(1-5)	(48-183)	(22-67)	(8-16)	(301-706)	(13-60)
Combined (n=88)						
M	3.7	122.2	44.3	11.5	487.7	40.7
SD	0.7	24.4	9.8	1.9	83.9	9.4
(min-max)	(1-5)	(48-183)	(22-67)	(8-16)	(301-706)	(13-60)

[1] Participants $\geq$ 35 years of age did not perform ergometer tests.

who were representative of the Canadian military population. That is, according to gender, age, physical size and level of fitness, to test sufficient numbers of subjects whose physical characteristics and preparedness spanned the various CF normative subgroups. Table 5 (section A) illustrates this distribution according to EXPRES norms. In general, an acceptable partitioning of subjects was achieved as classified from 'poor' through 'excellent' (i.e., the sample was normally distributed with respect to the EXPRES classification). Among the exceptions to this trend were male personnel < 35 years of age achieving above-average in pushups and situps, and female personnel < 35 years scoring lower than average on combined grip.

Overall, it was concluded that representative samples of male and female personnel < 35 years and males ≥ 35 years participated in the present study. On the other hand, the eight female personnel, aged 35-38 years, were not considered representative, nor was this sample size adequate for statistical purposes (see Section A3). Throughout section B, therefore, data for these eight subjects is reported in descriptive terms only; inferences are limited both because of the sample itself and that fact that these subjects also were restricted in their performances (being ≥ 35 years as described above).

Examining the laboratory test results, one finding seemed curious but was considered not to be of major consequence: the significantly longer endurance grips recorded by both ≥ 35 year old groups, compared to their counterparts < 35 years. For the females ≥ 35 years, this finding could be explained on the basis of the small and non-representative subject sample. For the sample of 41 males ≥ 35 years, this reasoning is less reliable, but the observed differences are not attributable to differences in physical size and/or maximum grip strength. As pointed out in the final report for MPFS I (Stevenson et al., 1985), it was again noteworthy how the larger size, muscle mass and inherent physiological capacities of males affected the present results. For example, maximal oxygen consumption expressed in millilitres of uptake per minute per kilogram of the subjects' body weight (the traditional units for expressing VO_2 max) minimized the discrepancy between the male and female personnel (Astrand and Rodahl, 1977). Similarly, when size, and thus muscle mass, was taken into account, the differences in combined grip between the males and females were also minimized (compare Tables B1.2b with A2). Modified protocols more suited to capacity (for example pushup scores) resulted in almost identical test scores for all groups. On several of the laboratory tests, however, partialling out size and capacity factors were not possible (compare Tables B1.3 with A3), yet many women proved successful at completing the various military tasks. From these perspectives, therefore, results from the present study must be interpreted with considerable insight. Physical capacity, per se, should not prejudice interpretation. And while physical preparedness is certainly an important factor it is not the only factor influencing task performance, particulary when protocol modifications clearly appear possible.

B1.5 Conclusions

1. Fitness testing carried out in the present study profiled three military groups: male personnel < 35 years (n=71); female personnel < 35 years (n=88); and male personnel ≥ 35 years (n=41). In general, each subgroup was representative of their respective CF population when compared to military EXPRES normative data and other size and gender related criteria.
2. Female personnel aged 35 to 38 years (n=8) were not representative of their particular military population; hence, data from this limited number may have little relevance to the present CF profile for women in this age group (at present, females ≥ 35 years make up 2,000 of 83,000 CF personnel). Their exclusion from the present data analysis does restrict the scope of this study to some degree, however, this does not limit data interpretation and conclusions drawn on the other groups of subjects, only comparative analyses involving this group.

SECTION B2

LOW HIGH CRAWL TASK ANALYSIS

SECTION B2

LOW HIGH CRAWL TASK ANALYSIS

B2.1 Introduction

Simulating a combat situation where personnel are pinned down by enemy fire, completion of this emergency task required that two crawling techniques be employed: through a 30 m course, over grassy terrain, leopard (low) crawl; then on hands and knees, a high (kitten) crawl for 45 m.

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) the low high crawl consistently has been shown to be physically demanding; maximal heart rate response and near-maximal blood lactate post-exercise values are elicited, confirming both the task's high aerobic and anaerobic energy requirements (respectively). However, since the physiological response is near-maximal in all subjects, such parameters have shown very low correlation with task performance (Stevenson *et al.*, 1985). Therefore, time was the only performance criteria recorded in the present MPFS phase.

Heart rates were monitored only as a safety precaution for subjects ≥ 35 years. Because of the strenuous nature of this task, these subjects were forced to pace themselves throughout their performance such that their heart rate was < 90% predicted maximal; if not, these personnel were stopped and not permitted to continue.

A potential source of error noted in performance of this task in the earlier phase, MPFS I, was subjects' low crawl technique. In many cases these subjects actually did not perform the leopard crawl or performed it very poorly, raising too high off the ground. Thus, the task protocol was revised in an effort to control this source of subject variation. The first modification was the placement of 16 barriers, 45 cm in height, 180 cm wide, at 2 m intervals, along the initial 30 m of the course (see Appendix C). In preliminary work these barriers and their close proximity along the 30 m course forced subjects tc execute the low crawl as it should be performed. Secondly, participants were provided extensive instruction in technique, which included an opportunity to practice on a shortened course (i.e., with 10 m low and 20 m high crawl sections) before being tested. Feedback was given during this practice phase in an attempt to ensure maximum performance by participants, and also to maximize the reliability of the test. Pilot work with this protocol, using 20 subjects, provided test-retest reliability coefficients for low crawl time, high crawl time, and total time of r=0.90, 0.81 and 0.93, respectively (see Appendix D).

One final modification was also introduced, namely the criterion completion time. Preliminary work indicated that forcing subjects to move under these barriers resulted in increased performance times. Further, as argued in the Final Report of MPFS I, 90 seconds for completion of the low high crawl was the standard established for elite United States Marine combat personnel; the validity of this as a standard for the general military population is questionable. Therefore, the time criteria was lengthened from the 90 seconds initially specified by the CF. In the present study, 134 seconds was identified as the time in which 75% of the sujects completed this modified crawl course (see Section A3.4 of present report).

B2.3 Task Protocol

At both CFB Borden and Ottawa, open grassy areas were chosen as course sites. In total, the distance required was 75 m, 30 m for the low course, then 45 m coming back (alongside and parallel to the low course portion) to the finish line. Over the first 30 m a low chute was constructed by placing a series of 16 barriers at 2 m intervals, wooden crossbars 45 cm off the ground, each supported by two metal posts aligned 180 cm apart (see Appendix C).

In full combat gear, including helmets, fatigues, carrying rifle (but with elbows and knees well-padded to prevent abradement), the subject started in a prone position, elbows, stomach, thighs and knees on the ground, the hands supporting a (simulated) M16 rifle held out in front (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 grass surface 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 split times recorded (in seconds) through the course were: i) through the low-crawl portion, at 20 m and at completion at 30 m; ii) through the high-crawl portion, at 50 m and at completion at 75 m; and iii) total time.

B2.4 Results

In Table B2.1 split times for subjects through the low high crawl course, to 75 m, are shown. In all instances, low-crawl times were slower than high-crawl times, and personnel ≥ 35 years forced to pace themselves in order to complete the course recorded slower times than their younger counterparts (i.e., of the same gender). On average, males completed the course faster than the female groups, reflecting their faster split-times through the course; as well, the ratio of their low-to-high crawl times was smaller for both groups of men. Individually however, females recording the faster times finished well ahead of the slower males in both age classifications; in fact, the two fastest females ≥ 35 years, even paced, finished ahead of several males < 35 years.

The four B2.2 tables present correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to these performance times: specifically, total time over the crawl course, Table B2.2a; low crawl times, Table B2.2b; high crawl times, Table B2.2c; and ratio of low-to-high crawl times, Table B2.2d. As seen from these tables, while individual r-values approached 0.6, no consistent pattern of relationship was observed. For the woman < 35 years, the various performance times correlated most consistently with their pushup, flexed arm

Table B2.1

Low-High Crawl Performance by Sex and Age Level.

	Low Crawl Time (s) 0 to 10 m	Low Crawl Time (s) 10 to 30 m	Low Crawl Time (s) Total	High Crawl Time (s) 30 to 50 m	High Crawl Time (s) 50 to 75 m	High Crawl Time (s) Total	Ratio LCT/HCT	Total Time (s)
Women < 35 years (n=84)								
M	18.7	59.9	78.6	30.4	30.4	60.6	1.3	139.3
SD	6.6	22.2	26.8	9.8	14.4	16.0	0.4	38.7
(min-max)	(9-55)	(25-132)	(34-163)	(3-86)	(17-144)	(31-152)	(.7-3.8)	(73-315)
Women ≥ 35 years (n=5)								
M	27.6	72.0	99.6	39.0	27.8	66.8	1.5	166.4
SD	12.2	32.8	45.0	9.8	6.1	15.1	0.4	58.8
(min-max)	(19-49)	(50-130)	(71-179)	(31-56)	(21-36)	(52-92)	(1.1-1.9)	(131-271)
Men < 35 years (n=65)								
M	11.1	32.0	43.0	20.8	20.6	41.4	1.0	84.4
SD	2.7	10.3	12.8	4.4	6.0	8.8	0.2	19.3
(min-max)	(7-21)	(18-68)	(26-89)	(11-32)	(10-42)	(25-71)	(.5-1.7)	(53-148)
Men ≥ 35 years (n=28)								
M	16.9	42.4	59.3	28.3	25.6	53.9	1.1	113.2
SD	6.5	17.9	23.9	8.9	12.1	15.3	0.3	35.0
(min-max)	(7-35)	(19-103)	(26-135)	(12-50)	(17-83)	(30-109)	(.5-1.8)	(56-212)

Table B2.2a

Correlations Between Low (High Crawl) Performance Measures and Fitness Parameters by Sex and Age Level: Total Time.

	Total Time		
	Women < 35 years	Men < 35 years	Men $\geq$ 35 years
Anthropometry			
Age	0.15	0.21	0.13
Height	0.12	-0.33	-0.02
Weight	0.22	0.06	-0.15
Muscular Strength and Endurance			
	*		*
Situp	-0.53	-0.15	-0.46
Pushup	-0.52*	-0.15	-0.51*
Combined Grip	-0.22	-0.07	-0.34
Endurance Grip	[illegible]	-0.21	-0.30
Flexed Arm Hang	-0.58*	-0.49*	-0.26
Max. ILM to 100	-0.21	-0.23	-0.27
Max. ILM to 152	-0.26	-0.21	-0.28
Aerobic Capacity			
	*		
Step Test	-0.40	-0.10	-0.30
Anaerobic Capacity			
Upper Body (Arm Ergometer)			
Total Work	-0.23	-0.05	
Peak Power	-0.23	-0.05	
Percent Drop Off	0.16	0.20	
Lower Body (Leg Ergometer)			
Total Work	-0.26	-0.01	
Peak Power	-0.12	0.13	
Percent Drop Off	0.18	0.31	

Note: i) Correlation coefficients were not computed for $\geq$ 35 year-old women due to small number of subjects in group.

ii) Coefficient of r $\geq$ .38 required for significance at p < [illegible].*

Table B2.2b

Correlations Between Low Crawl Performance Measures and Fitness Parameters by Sex and Age Level: Low-Crawl.

	0 to 10 m			10 to 30 m			Total Time		
	Women	Men		Women	Men		Women	Men	
	< 35 years	< 35 years	> 35 years	< 35 years	< 35 years	> 35 years	< 35 years	< 35 years	> 35 years
Anthropometry									
Age	0.20	0.11	0.21	-0.01	0.02	0.01	0.05	0.04	0.06
Height	0.01	-0.32	0.005	0.08	-0.26	-0.07	0.07	-0.28	-0.05
Weight	0.25	-0.04	-0.12	0.29	-0.06	-0.08	0.30	-0.05	-0.09
Muscular Strength and Endurance									
Situps	-0.22	-0.10	-0.42	-0.53	0.01	-0.41	-0.49	-0.02	-0.42
Pushups	-0.40	-0.28	-0.46	-0.51	-0.32	-0.44	-0.52	-0.32	-0.45
Combined Grip	-0.12	-0.08	-0.16	-0.25	-0.11	-0.20	-0.24	-0.11	-0.19
Endurance Grip	-0.16	-0.15	-0.20	-0.42	-0.22	-0.21	-0.38	-0.21	-0.21
Flexed Arm Hang	-0.41	-0.31	-0.25	-0.51	-0.34	-0.22	-0.53	-0.34	-0.23
Max. ILM to 183	-0.13	-0.20	-0.24	-0.18	-0.16	-0.14	-0.18	-0.17	-0.17
Max. ILM to 152	-0.17	-0.16	-0.31	-0.23	-0.16	-0.14	-0.24	-0.16	-0.19
Aerobic Capacity									
Step Test	-0.33	0.02	-0.40	-0.31	0.06	-0.37	-0.34	0.05	-0.39
Anaerobic Capacity									
Upper Body (Arm Ergometer)									
Total Work	-0.14	-0.04		-0.22	-0.04		-0.22	-0.04	
Peak Power	-0.14	-0.04		-0.22	-0.04		-0.22	-0.04	
Percent Drop-Off	0.18	0.07		0.20	0.14		0.21	0.13	
Lower Body (Leg Ergometer)									
Total Work	-0.24	-0.03		-0.29	-0.03		-0.30	-0.03	
Peak Power	-0.18	0.05		-0.15	0.12		-0.17	0.11	
Percent Drop-Off	0.01	0.19		0.16	0.27		0.14	0.26	

Notes: $r > 0.38$ required for significance $p < .001$.

Table B2.2c

Correlations Between Low-High Crawl Performance Measures and Fitness Parameters by Sex and Age Level: High Crawl

	30 to 50 m			50 to 75 m			Total Time		
	Women	Men		Women	Men		Women	Men	
	< 35 years	< 35 years	≥ 35 years	< 35 years	< 35 years	≥ 35 years	< 35 years	< 35 years	≥ 35 years
Anthropometry									
Age	0.22	0.33	-0.01	0.12	0.31	0.26	0.27	0.38	0.21
Height	-0.05	-0.26	-0.19	-0.18	-0.31	0.18	-0.07	-0.33	0.04
Weight	0.28	0.20	-0.08	-0.04	0.16	-0.21	0.27	0.21	-0.21
Muscular Strength and Endurance									
Situp	-0.42	-0.21	-0.32	-0.25	-0.28	-0.24	-0.45	-0.30	-0.38
Pushup	-0.35	-0.37	-0.41	-0.25	-0.20	-0.28	-0.39	-0.32	-0.46
Combined Grip	-0.12	-0.09	-0.16	-0.11	0.05	-0.47	-0.15	-0.01	-0.47
Endurance Grip	-0.19	-0.19	-0.23	-0.27	-0.09	-0.27	-0.23	-0.16	-0.35
Flexed Arm Hang	-0.48	-0.48	-0.16	-0.19	-0.52	-0.16	-0.51	-0.60	-0.22
Max. ILM to 183	-0.15	-0.28	-0.28	-0.21	-0.16	-0.43	-0.21	-0.25	-0.50
Max. ILM to 152	-0.20	-0.20	-0.28	-0.23	-0.20	-0.46	-0.24	-0.23	-0.52
Aerobic Capacity									
Step Test	-0.38	-0.27	-0.32	-0.14	-0.22	0.14	-0.39	-0.29	-0.07
Anaerobic Capacity									
Upper Body (Arm Ergometer)									
Total Work	-0.21	-0.11		-0.34	-0.01		-0.21	-0.06	
Peak Power	-0.21	-0.11		-0.34	-0.01		-0.21	-0.06	
Percent Drop Off	0.00	0.30		-0.07	0.16		0.02	0.26	
Lower Body (Leg Ergometer)									
Total Work	-0.10	-0.07		-0.24	0.08		-0.13	0.02	
Peak Power	0.01	0.06		-0.16	0.15		-0.01	0.13	
Percent Drop Off	0.18	0.26		0.10	0.28		0.21	0.32	

Notes: $r > .38$ required for significance at $p < .001$

Table B2.2d

Correlations Between Low-High Crawl Performance Measures and Fitness Parameters by Sex and Age Level: Ratio Low- to High-Crawl Time.

	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry			
Age	-0.21	-0.27	0.02
Height	0.15	-0.10	0.01
Weight	0.09	-0.24	0.003
Muscular Strength and Endurance			
Situps	-0.21	0.24	-0.26
Pushups	-0.27	-0.17	-0.28
Combined Grip	-0.17	-0.12	0.09
Endurance Grip	-0.30	-0.15	0.01
Flexed Arm Hang	-0.24	0.06	-0.11
Max. ILM to 183	-0.20	-0.04	-0.02
Max. ILM to 152	-0.22	-0.01	-0.04
Aerobic Capacity			
Step Test	-0.02	0.24	-0.48
Anaerobic Capacity			
Upper Body (Arm Ergometer)			
Total Work	-0.11	0.01	
Peak Power	-0.11	0.01	
Percent Drop Off	0.17	-0.04	
Lower Body (Leg Ergometer)			
Total Work	-0.28	-0.02	
Peak Power	-0.25	0.03	
Percent Drop Off	-0.06	0.05	

Notes: $r > .38$ required for significance at $p < .001$

hang and situp scores. For young men < 35 years, their low crawl performance produced no significant relationships when correlated to physical fitness variables while high crawl and total times correlated best with their flexed arm scores. On the other hand, for men $\geq$ 35 years both their low- and high-crawl performance times correlated most consistently with their pushup and situp scores. As well, aerobic capacity appeared related to performance because these subjects were 'paced'. Finally, consistently low (and insignificant) r-values were found correlating the ratio of subjects low to high crawl times and any of their fitness parameters.

Results of the stepwise regression analyses of low high crawl total time on EXPRES and laboratory test variables are shown in Table B2.3. For females < 35 years, again both the flexed arm hang and situps (R^2=0.38) appeared as significant predictor variables, whereas for their male counterparts (men < 35 years) only the flexed arm hang (R^2=0.23) was accepted in this analysis. On the other hand, for men $\geq$ 35 years stepwise regression produced no reliable variables for a prediction equation (see second footnote below Table B2.3). 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 and endurance, aerobic capacity, both upper- and lower-body anaerobic capacity, etc.). For women < 35 years, by far the greatest change in R^2 (0.40) was accounted for by their strength-endurance component when compared to other variables in the equation. Similarly, for men < 35 years, the strength-

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	MultR	R^2	F	p
Women < 35 years						
Constant	160.0	5.74				
Flexed Arm Hang	-1.0	0.30	0.56	0.31	27.7	<.001
Situps	-1.0	0.38	0.61	0.38	18.5	<.001
Men < 35 years						
Constant	103.6	5.92				
Flexed Arm Hang	-0.5	0.12	0.48	0.23	15.3	<.001

Note: 1) Regression analyses were not completed for women $\geq$ 35.

2) The regression analysis for older men indicated no reliable variables in equation.

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	0.126	4.03	<.01	0.126	4.03	<.01
Strength and Endurance	0.527	8.59	<.001	0.402	9.35	<.001
Aerobic Capacity	0.528	7.73	<.001	0.001	0.11	<.05
Lower Body Anaerobic	0.576	7.08	<.001	0.048	2.74	<.05
Upper Body Anaerobic	0.590	6.38	<.001	0.014	1.21	<.05
Men < 35 years						
Anthropometric	0.088	2.16	>.05	0.088	2.16	>.05
Strength and Endurance	0.331	2.97	<.01	0.243	3.11	<.01
Aerobic Capacity	0.334	2.68	<.01	.003	0.24	>.05
Lower Body Anaerobic	0.398	2.65	<.01	0.065	2.00	>.05
Upper Body Anaerobic	0.413	2.38	<.01	0.015	0.68	>.05
Men ≥ 35 years						
Anthropometric	0.027	0.34	>.05	0.027	0.34	>.05
Strength and Endurance	0.278	1.15	>.05	0.250	1.48	>.05
Aerobic Capacity	0.339	1.35	>.05	0.062	2.73	>.05

endurance component accounted for the greatest R^2 change (0.24) in comparison to the other variables. And for the men $\geq$ 35 years, of the fitness components regressed, (i.e., the lower- and upper-body anaerobic components were not determined in the $\geq$ 35 subject groups) their strength-endurance component again accounted for the greatest change in R^2 (0.25).

Discriminant function analysis (Table B2.5) using a stepwise procedure (testing both EXPRESS and the other fitness variables) indicated different patterns of discriminating variables for each of the three groups. For young men, although two variables were identified, the function was not significant; that is, the variables identified could not reliably discriminate between passers and failers for this group. However, significant functions were obtained for young women and men $\geq$ 35 years. For the former, situps, flexed arm hang and endurance grip time were included in the analysis and the resultant function correctly classified 80.6% of the cases. For the latter group, men $\geq$ 35 years, 92.9% were correctly classified into passing/failing groups based on the variables situps, combined maximum grip, predicted $VO2_{max}$ and flexed arm hang.

B2.5 Interpretation

Independent of groupings, subjects completed the longer, final portion of the course (despite approaching fatigue) in a faster time than the initial, shorter low-crawl portion. This proved a direct reversal of results observed in MPFS I (Stevenson et al., 1985). This observation, therefore, appeared to substantiate the necessity for the overhead barriers along the

Table B2.5

Discriminant Analysis and Classification Results by EXPRES and Queen's Variables on Groups Defined by Low-High Crawl Task Pass Criteria of 140 Seconds.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Performance Status	n	%	Predicted Performance Correctly Classified n	%	Incorrectly Classified n	%
Women < 35 years								
Situps	0.77	Pass	41	(61.2)	36	(87.8)	5	(12.2)
Flexed Arm Hang	0.31	Fail	26	(38.8)	18	(69.2)	8	(30.8)
Endurance Grip	0.27							
		Total	67		54	(80.6)	13	(19.4)
Wilks' Lambda:	0.70							
Chi-Squared:	22.57							
Significance Level:	< .001							
Men < 35 years								
VO2 Max	0.69	Pass	61	(98.4)	61	(100.0)	0	(0.0)
ILM Max to 183 cm	-0.59	Fail	1	(1.6)	0	(0)	1	(100.0)
		Total	62		61	(98.4)	1	(1.6)
Wilks' Lambda:	0.93							
Chi-Squared:	4.46							
Significance Level:	NS							
Men ≥ 35 years								
Situps	0.84	Pass	22	(78.6)	22	(100.0)	0	(0.0)
Combined Max Grip	0.62	Fail	6	(21.4)	4	(66.7)	2	(33.3)
VO2 Max	0.87							
Flexed Arm Hang	-0.60							
		Total	28		26	(92.9)	2	(7.1)
Wilks' Lambda:	0.67							
Chi-Squared:	9.79							
Significance Level:	< .05							

shorter course, thereby forcing subjects to perform the more technically difficult leopard crawl more skillfully. Further, the forced pacing of subjects $\geq$ 35 years regardless of gender retarded their progress through the course by a constant decrement: for the males, a mean difference was observed of 28.8 seconds slower compared to their younger counterparts < 35 years; for females $\geq$ 35 years, mean completion time was 27.1 seconds slower than that of younger females. Because of these factors (technically correct performance, forced pacing, etc.), the criterion time of 90 seconds for 'successful completion', as initially directed by the CF and based upon U.S. Marine combat standards, appeared non-sequitur within the present context. For example, of subjects $\geq$ 35 years only 21% of the males and none of the females achieved this criterion; even worse, for subjects < 35 years only 61% of males and 8% of females 'passed'.

Therefore, it seemed imperative that a more reasonable time standard be established for the low high crawl, based upon the time which the fastest 75% of subjects achieved but which the slowest 25% of subjects failed to achieve; the rationale for this arbitrary point of demarcation, 75%-25%, is argued in Section A3.4. Empirically, 134 seconds was determined as the criterion time (see Figure A2.a). (This was rounded to 140 s to provide a standard measure for future studies.) Further, based upon the correlation analyses summarized in Tables B2.2a-d, total time (for completion of the low high crawl) was accepted as the optimal measure for evaluating subjects' performances because of its simplicity and relationship to physical fitness: that is, the other analyses comparing various performance times (i.e., splits, ratio low-to-high, etc.) 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. Finally, the stepwise and block regression analyses and the discriminant function analyses generally confirmed that the most important fitness component for low high crawl performance was strength-endurance, with specific combinations of fitness being required according to the subject group. For the younger men, it appeared they took advantage of their greater upper body strength to propel themselves through both the low and high crawl portions of the course. For the women < 21 and men ≥ 35 years, greater dependence was placed on trunk muscles than upper body musculature (as reflected in the significant relationships of their performance times to situps); these subjects used the knees and pelvis, moving forward, securing contact with the ground, in order to aid their performance in both (low and high) crawling motions. For men ≥ 35 years, predicted VO_2 max was also identified as a discriminating variable between passers and failers; this undoubtedly was related to our testing procedure of forced pacing.

In Table B2.6, the PASSERS within the individual groups (i.e., the 75% of subjects meeting the pass criterion) are profiled according to their EXPRES and other laboratory test scores. From the analyses in Tables B2.2, B2.3 and B2.4, none of the other laboratory test items were shown to be either more highly or consistently related to performance and, therefore, were not considered further in the development of minimum

Table B2.6

Fifth Percentile Scores for Personnel Passing Low-High Crawl by Sex and Age Level.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
EXPRES			
Max Grip	42.5	74.4	76.5[a]
VO2 Max	31.7b	40.0	35.4[a]
Pushups	21.0[b]	12.9[b]	17.0[b]
Situps	23.9[a,b,c]	21.6	27.3[d,b]
Queen's			
ILM max to 183 cm	15.1	31.9	27.8
ILM max to 152 cm	18.6	35.2	33.0[b]
Flexed Arm Hang	-3.0[a,b,c]	14.8[b,c]	18.9[a,b,c]
Endurance Grip	25.9[a]	34.3	86.0
Arm Ergometer:			
Total Work	2610.7	5182.6	
Peak Power	87.0	172.8	
% Drop-Off	27.4	31.4	
Leg Ergometer:			
Total Work	8882.8	13465.8	
Peak Power	369.4	534.8	
% Drop-Off	24.0	27.7	

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

fitness. Based upon normalized distributions of passers' scores from the particular subject groups, as explained at length in section A3.5 the minimum EXPRES values determined in Table B2.6 have been arbitrarily set at the 5th percentile. However, there are substantial differences in these 'minimum' fitness standards according to the subject groupings which appear noteworthy. Specifically:

- the minimum for grip strength was almost 50% less for women < 35 years than for either group of men;
- differences in VO_2 max shown to be unrelated to low high crawl performance, appeared to merely reflect expected physiological differences due to aging (i.e., 5% decrement per decade, comparing the older versus younger men), and gender (i.e., 15-25% difference between males and females of the same age) (Astrand & Rodahl, 1977);
- the minimums for pushups, a significant variable in both low and high crawling, suggest that as a subjects' innate strength decreased this minimum value increased; this apparent anomaly may be accounted for by the marked difference in test protocol for pushups for women and men (as dictated by the required EXPRES protocol).

In Table B2.7, the efficacy of these minimum fitness criteria determined across all tasks is tested relative to subject's actual low high crawl performance times. By group, on the basis of their fitness, 65.8% of women < 35 years were correctly classified as 'passers', while 79.4% of men < 35 and 78.6% of males $\geq$ 35 were correctly classified. In contrast, of those predicted to fail according to this MPFS subset, by group

Table B2.7

Ability of Minimum Physical Fitness Standards (Based on All Tasks) to Correctly Predict Performance on Low-High Crawl.

	Actual Task Performance		Predicted Performance			
			Correctly Classified		Incorrectly Classified	
	n	(%)	n	(%)	n	(%)
Women < 35 years						
Passed Crawl	46		40 (true positives)		6 (false negatives)	
Failed Crawl	30		10 (true negatives)		20 (false positives)	
Total	76		50	(65.8%)	26	(34.2%)
Men < 35 years						
Passed Crawl	62		50 (true positives)		12 (false negatives)	
Failed Crawl	1		0 (true negatives)		1 (false positives)	
Total	63		50	(79.4%)	13	(20.6%)
Men ≥ 35 years						
Passed Crawl	22		20 (true positives)		2 (false negatives)	
Failed Crawl	6		2 (true negatives)		4 (false positives)	
Total	28		22	(78.6%)	6	(21.4%)

(respectively) 33.3% versus 0% and 66.7% of subjects were correctly classified. In each group there were relatively low numbers of subjects who actually passed the low high crawl but were predicted to fail (7.9%, 19.0%, and 7.1%, respectively, for the three groups). On the other hand, false positive classifications were fairly high for all three groups (i.e., based on total number of subjects in each group, 26.3%, 1.6% and 14% for young women, young men and older men, respectively).

B2.6 Conclusion

From these data, the conclusions to be drawn concerning task performance are limited by the lack of definitive statistical relationships. Therefore, within these delimitations the following conclusions appear warranted:

1. Generally, upper-body strength-endurance is the most important fitness component in performance of the low high crawl (Stevenson et al., 1985); conversely, the weaker the upper-body musculature the more one uses trunk and leg muscles to assist in propelling the body.
2. These data suggest that the most significant variables related to one's performance in the low high crawl incorporate a unique set of fitness capacities according to the subject's classification.
3. However, grip strength and predicted aerobic capacity appear not to be important variables.
4. MPFS based upon EXPRES variables are of limited value as discriminators of performance success on the low high crawl and additional laboratory tests improved performance prediction only marginally (Stevenson et al., 1985).

SECTION B3

LAND STRETCHER EVACUATION ANALYSES

SECTION B3

LAND STRETCHER EVACUATION 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, one major modification in the protocol was implemented for MPFS II as well as several more minor alterations in data collection procedures. However, the performance criterion of 20 minutes for completion of the evacuation was retained because 75% of all subjects in the present study achieved this criteria; in MPFS I 71% of all subjects bettered 20 minutes in the land evacuation task. In consultation with D.C.I.E.M. and ranking CF Officer personnel, a "pass" ratio of 75% (versus 25% of subjects failing) was deemed an appropriate benchmark.

B3.2 Task Rationale

To complete the land evacuation twenty minutes of heavy exercise must be performed (Astrand and Rodahl, 1977) and clearly the data from MPFS I underscored this fact: heart rates, monitored throughout the evacuation and at completion, were strikingly similar for all subjects regardless of age or gender, on average 168 - 169 beats/minute (Stevenson et al., 1985). As a consequence, physiological parameters discriminated between subjects minimally, proving poor predictors of task performance; therefore, in the present phase of MPFS physiologic variables were not recorded. Heart rate monitoring was employed in the interests of safety only with subjects $\geq$ 35 years.

The most acute problem 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 MPFS I, from subjective observation it appeared that this problem was exacerbated by two compounding factors. Foremost, the number of stops (i.e., a forced set-down of the stretcher by the subject) was dictated by the strength-endurance of the weaker wrist, usually the non-dominant forearm which fatigued more quickly, 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). Secondly, in MPFS I, the 'other' end of the land stretcher was carried by laboratory personnel switching-off when ever tired. From subjective assessment, however, this in practice produced created two problems: i) a degree of uncoordination between subject and the test personnel on the other end, particularly over the latter half of the course as fatigue set in as well as during set-downs; and, ii) whenever the laboratory personnel switched this cost the subject time.

During preliminary studies in the spring of 1986, several protocol modifications were instituted for MPFS II in an effort to develop a 'purer' task. Most significantly, a set of two wheels was affixed below the rear end of the land-stretcher making this evacuation a one-person task. This resulted in several advantages over the previous technique. Through the wheel-and-axle mechanism, in any given subject one's stronger wrist could support a greater proportion of the load, albeit small relative to the entire 80 kilograms but enough to spell-off the weaker wrist. The load itself could be positioned on the stretcher more comfortably for carriage, and attached securely so as to minimize the inertial recoil of the load with each step. The stretcher bed could be adjusted on the wheels according to the height of subjects (which ranged from 152 cm to 196 cm in MPFS II) so that the stretcher was always horizontal (i.e., exactly parallel to the ground) when being carried. To assist in set-down 2 legs, each a meter in height, were attached underneath the front end of the stretcher; thus, with only a bend of the knees a subject could set the stretcher down, reducing the skill and increasing the safety required for this manoeuver. The only minor disadvantage to the addition of wheels appeared to be that subjects had to pull the stretcher (like a ricksha), presumably adding slightly to the total work performed. Pilot work with this protocol, using eight participants, provided a test-retest reliability coefficient of r=0.94 (see Appendix D).

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). Carrying a load one-half the body weight elicits a heavy physiological response of 75% of that subject's maximal aerobic capacity (Gordon et al, 1983); for the lighter subjects, both in MPFS I and the present study, the 80 kg stretcher loading often exceeded this value, and the faster these subjects attempted to move the proportionately greater amount of their relative aerobic capacity was required (Soule et al, 1978). Therefore, at CFB Borden weight was added onto the stretcher bed incrementally with the series of reduced loads (i.e., 40 kg, then 60 kg, then the entire 80 kg) being carried as quickly as possible over a reduced distance (250 m) in an effort to determine a threshold loading - a specific carriage weight at which a subjects' physiological responses might suddenly increase and/or performance time decrease disproportionately.

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 to be evacuated. The height of the stretcher bed was also adjustable according to the height of the subject.

At CFB Borden the stretcher was carried around a 400 m hard-surfaced, cinder track 2 1/2 times (to complete 1 km). At CFB Ottawa, the stretcher carry was performed indoors around a 100 m course set out around a large arena floor, with 10 laps to complete 1 km; otherwise, the task protocol was identical. Distance markers were positioned around the track both to indicate to subjects their distance travelled 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 at a self-determined pace; as well, the frequency and duration of set-downs were left to the discretion of the subject.

Incremental stretcher carrying (at CFB Borden only) consisted of four phases, which were conducted over the same cinder track. Phase 1 involved carrying the stretcher empty (i.e., unweighted) as quickly as possible over 250 m; phases 2, 3 and 4 were also 250 m in length, performed in random order, and involved carrying the equivalent of 40 kg, 60 kg, and 80 kg.

At both test sites the variables recorded were split-times at completion of 250 m, 500 m and 750 m, and total time to complete to 1 km. During the Incremental Testing (at CFB Borden) only the time to 250 m, (the total length of this task format), was recorded.

B3.4 Results

In Table B3.1, total times for completion of the land evacuation task and split-times are presented. On average, both subject groups $\geq$ 35 years completed the task in faster times than their younger counterparts, a trend also reflected in split-times. Men completed the evacuation 6.5 minutes faster than female personnel, with fewer set-downs being required during their carry; on the other hand, substantial overlap again was noted between a number of the faster females and almost one-third of the slower males. In Table B3.2 the Incremental Test performances by subjects at CFB Borden are presented. The unweighted stretcher carry *in effect* provided a measure of these

Table B3.1

Land Evacuation Task Performance Scores by Sex and Age Level.

	Split Times				Total Time	
	0 to 250 m	250 to 500 m	500 to 750 m	750 to 1000 m	(s)	(min)
Women < 35 years (n=77)						
M	233.0	320.1	361.8	336.1	1171.1	20:01
SD	79.8	145.5	144.2	138.1	410.2	6:09
(min-max)	(112-516)	(147-1013)	(163-918)	(160-1110)	(482-2754)	(10-46)
Women ≥ years (n=7)						
M	238.1	323.6	366.5	314.3	1146.3	19:06
SD	75.8	112.7	172.4	113.2	342.0	5:42
(min-max)	(155-356)	(208-525)	(184-745)	(195-529)	(747-1796)	(12-30)
Men < 35 years (n=69)						
M	147.9	196.9	227.4	213.9	786.1	13:06
SD	243.0	72.3	76.7	85.8	233.8	3:53
(min-max)	(75-243)	(36-417)	(91-437)	(84-499)	(379-1451)	(6-24)
Men ≥ 35 years (n=41)						
M	158.6	185.1	204.1	201.6	750.6	12:31
SD	34.6	47.6	61.3	49.8	174.8	2:55
(min-max)	(83-232)	(114-288)	(117-335)	(122-322)	(444-1145)	(7-19)

Table B3.2

Performance Scores for Incremental Stretcher Carry Task by Sex.[1]

	Unloaded Stretcher Time (s)	40 kg Loading Time (s)	40 kg Loading Drop-off (%)	60 kg Loading Time (s)	60 kg Loading Drop-off (%)	80 kg Loading Time (s)	80 kg Loading Drop-off (%)
Women < 35 years (n=21)							
M	114.5	149.8	36.1	206.7	84.2	256.3	134.9
SD	32.2	37.9	20.4	114.8	71.8	87.3	83.2
(min-max)	(84-203)	(103-256)	(-2-77)	(103-670)	(18-363)	(126-451)	(49-401)
Men < 35 years (n=41)							
M	70.6	90.6	28.9	110.4	57.5	141.5	99.0
SD	10.3	15.5	18.1	36.6	51.3	53.2	58.0
(min-max)	(56-97)	(64-128)	(-2-77)	(73-104)	(6-322)	(84-321)	(21-251)

1 Testing for this task conducted at CFB Borden only, thus, there are no data available for the older age groups.

2 Percentage Drop-Off calculated relative to subjects' unloaded 'baseline' times to 250 m:

$$\% \text{ drop-off} = \frac{\text{load time} - \text{baseline time}}{\text{baseline time}} \times 100$$

subjects' potentials, that is, their absolute fastest carriage abilities for 250 m. When weight was incrementally added both their performance times in seconds, as well as performance expressed as a ratio of 'potential', i.e., percentage drop-off, declined proportionately with the greater loadings.

Tables B3.3a and B3.4 present correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to their performance times: specifically, total time over 1 km, Table B3.3a; split-times throughout the 1 km evacuation, Table B3.3b; and incremental loading of the stretcher, in Table B3.4 including times to 250 km and resultant performance drop-offs. As seen from Table B3.3a, for all subjects, only two (of 45) r-values were found to be significant at the (accepted) 0.001 level of confidence, while many approached zero. Although most of the relationships are in the expected direction (i.e., negative, the higher one's test scores, the less total time taken), in Table B3.3b, again, there appeared little relationship between split-times and fitness parameters: while several more r-values were found to be significant (10 of 144 coefficients) no consistent pattern was observed. Finally, in Table B3.4, several more r-values (32 of 224 coefficients) were found to be significant, relating subjects' incremental performance measures to their fitness, but again, there were no consistent patterns. Comparison of relationships between fitness parameters and the 80 kg loading of the incremental stretcher carry to those between fitness and the first 250 m split of the land evacuation yields quite different patterns

Results of analyses regressing total time on EXPRESS and

Table B3.3a

Correlations Between Land Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Total Time.

	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry			
Age	-0.10	-0.18	0.18
Height	-0.20	-0.20	-0.17
Weight	-0.12	-0.25	0.03
Muscular Strength/Endurance			
Situp	-0.06	-0.21	-0.37
Pushup	-0.06	-0.33	-0.50
Comb Grip	-0.19	-0.39	-0.04
End Grip	-0.23	-0.48	-0.29
Flexed Arm Hang	-0.14	-0.22	-0.29
Max ILM to 152 cm	-0.25	-0.32	-0.14
Max ILM to 183 cm	-0.30	-0.35	-0.26
Aerobic Capacity			
Step Test	-0.02	-0.02	-0.52
Anaerobic Capacity			
Upper Body (Arm Ergometer)			
Step Test	-0.32	-0.25	
Peak Power	-0.32	-0.25	
Percent Drop-Off	-0.13	0.16	
Lower Body (Leg Ergometer)			
Total Work (leg)	-0.28	-0.30	
Peak Power	-0.25	-0.21	
Percent Drop-Off	-0.001	0.18	

Notes: Coefficients of $r \geq |.38|$ required for significance at $p < 0.001$

Table B3.3b

Correlation Between Land Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Split-times.

	Split Times					
	0 to 250 m			250 to 500 m		
	Women < 35 years	Men < 35 years	Men ≥ 35 years	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry						
Age	-0.04	-0.22	0.05	-0.01	-0.13	0.19
Height	-0.22	-0.07	-0.12	-0.08	-0.25	-0.11
Weight	-0.17	-0.20	-0.07	0.05	-0.22	-0.02
Muscular Strength/Endurance						
Situp	-0.23	-0.24	-0.23	-0.29	-0.19	-0.36
Pushup	-0.28	-0.16	-0.30	-0.31	-0.27	-0.50
Combined Max Grip	-0.22	-0.19	0.01	-0.31	-0.37	-0.09
Endurance Grip	-0.28	-0.37	-0.20	-0.31	-0.37	-0.26
Flexed Arm Hang	-0.21	-0.13	-0.19	-0.23	-0.19	-0.24
Max ILM to 183 cm	-0.28	-0.38	-0.06	-0.23	-0.31	-0.22
Max ILM to 152 cm	-0.40	-0.37	-0.27	-0.29	-0.34	-0.38
Aerobic Capacity						
Step Test	-0.10	-0.01	-0.45	-0.27	-0.06	-0.48
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Step Test	-0.45	-0.15		-0.30	-0.24	
Peak Power	-0.45	-0.14		-0.30	-0.24	
Percent Drop-Off	0.07	0.15		-0.10	0.17	
Lower Body (Leg Ergometer)						
Total Work (leg)	-0.46	-0.30		-0.32	-0.38	
Peak Power	-0.33	-0.22		-0.15	-0.28	
Percent Drop-Off	0.21	0.10		-0.01	0.13	

Notes: $r \geq |.38|$ required for significance at $p < .001$.

Table B3.3b (cont)

	Split Times					
	500 to 750 m			750 to 1000 m		
	Women < 35 years	Men < 35 years	Men ≥ 35 years	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry						
Age	-0.14	-0.15	0.18	0.05	-0.15	0.20
Height	-0.28	-0.17	-0.12	-0.02	-0.14	-0.27
Weight	-0.12	-0.26	0.07	0.002	-0.16	0.08
Muscular Strength/Endurance						
Situp	-0.16	-0.24	-0.36	0.06	-0.09	-0.38
Pushup	-0.05	-0.33	-0.47	0.02	-0.31	-0.49
Comb Grip	-0.15	-0.37	0.01	-0.13	-0.32	-0.10
End Grip	-0.45	-0.50	-0.24	0.03	-0.40	-0.37
Flexed Arm Hang	-0.28	-0.15	-0.30	0.02	-0.23	-0.38
Max ILM to 183 cm	-0.23	-0.32	-0.08	-0.31	-0.17	-0.15
Max ILM to 152 cm	-0.25	-0.36	-0.14	-0.30	-0.18	-0.18
Aerobic Capacity						
Step Test	-0.13	-0.03	-0.55	0.03	0.02	-0.38
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Step Test	-0.38	-0.27		-0.06	-0.17	
Peak Power	-0.38	-0.27		-0.06	-0.17	
Percent Drop-Off	0.25	0.15		-0.30	0.09	
Lower Body (Leg Ergometer)						
Total Work (leg)	-0.37	-0.23		-0.02	-0.16	
Peak Power	-0.23	-0.16		-0.15	-0.11	
Percent Drop-Off	0.22	0.19		-0.26	0.17	

Notes: $r \geq |.38|$ is required for significance at $p < .001$.

Table B3.4

Correlation Between Incremental Stretcher Carry Performance Measures and Fitness Parameters by Gender and Age Level: Times to 250 m; Drop-Offs with Incremental Loading.

	Unloaded Stretcher Time		40 kg Loading			
			Time		Drop-off	
	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years
Anthropometry						
Age	-0.21	-0.13	-0.29	-0.04	0.08	0.11
Height	0.01	-0.12	-0.07	-0.10	-0.32	0.01
Weight	-0.02	-0.07	-0.45	-0.16	-0.35	-0.13
Muscular Strength/Endurance						
Situps	-0.62	-0.20	-0.43	-0.14	0.18	0.02
Pushups	-0.52	-0.19	-0.16	-0.25	0.45	-0.13
Combined Max Grip	-0.49	-0.22	-0.45	-0.38	-0.25	-0.22
Endurance Grip	-0.41	-0.41	-0.48	-0.40	-0.18	-0.08
Flexed Arm Hang	-0.58	-0.27	-0.44	-0.12	0.08	0.16
Max ILM to 183 cm	-0.32	-0.34	-0.29	-0.42	-0.03	-0.20
Max ILM to 152 cm	-0.28	-0.13	-0.38	-0.32	-0.30	-0.25
Aerobic Capacity						
Step Test	-0.16	-0.06	0.05	-0.19	-0.09	-0.16
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Total Work	-0.40	-0.24	-0.44	-0.21	-0.02	-0.03
Peak Power	-0.40	-0.24	-0.45	-0.21	-0.02	-0.03
Percent Drop-Off	0.43	0.33	0.26	0.11	-0.31	-0.18
Lower Body (Leg Ergometer)						
Total Work	-0.50	-0.21	-0.60	-0.25	-0.01	-0.11
Peak Power	-0.20	-0.08	-0.37	-0.24	-0.15	-0.22
Percent Drop-Off	0.40	0.33	0.41	0.09	0.02	-0.22

Notes: $r \geq |.38|$ required for significance at $p < .001$

Table B3.4 (cont)

	60 kg Loading				80 kg Loading			
	Time		Drop-Off		Time		Drop-Off	
	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years
Anthropometry								
Age	-0.31	0.05	-0.23	0.11	-0.30	-0.06	-0.10	0.04
Height	-0.30	-0.18	-0.45	-0.11	0.01	-0.32	-0.16	-0.30
Weight	-0.22	-0.26	-0.17	-0.23	-0.18	-0.22	0.02	-0.22
Muscular Strength/Endurance								
Situp	-0.13	-0.04	0.14	0.05	-0.19	-0.18	0.24	-0.11
Pushup	0.04	-0.21	0.29	-0.15	-0.13	-0.19	0.20	-0.12
Combined Max Grip	-0.24	-0.45	-0.15	-0.36	-0.41	-0.43	-0.18	-0.41
Endurance Grip	-0.34	-0.29	-0.24	-0.13	-0.58	-0.34	-0.34	-0.27
Flexed Arm Hang	-0.28	-0.03	-0.10	0.10	-0.34	-0.15	-0.01	-0.02
Max ILM to 183 cm	-0.20	-0.33	-0.13	-0.22	-0.18	-0.33	0.04	-0.26
Max ILM to 152 cm	-0.29	-0.37	-0.28	-0.31	-0.26	-0.37	-0.09	-0.37
Aerobic Capacity								
Step Test	0.01	-0.25	-0.03	-0.23	-0.11	0.13	-0.20	0.17
Anaerobic Capacity								
Upper Body (Arm Ergometer)								
Step Test	-0.29	-0.14	-0.15	-0.05	-0.17	-0.26	0.15	-0.22
Peak Power	-0.29	-0.14	-0.15	-0.05	-0.17	-0.26	0.16	-0.22
Percent Drop-Off	0.34	0.10	0.15	-0.03	-0.36	0.01	-0.68	-0.11
Lower Body (Leg Ergometer)								
Total Work (leg)	-0.35	-0.21	-0.13	-0.13	-0.20	-0.20	0.27	-0.16
Peak Power	-0.13	-0.15	-0.02	-0.13	-0.21	-0.19	0.03	-0.19
Percent Drop-Off	0.46	0.19	0.36	0.05	-0.10	0.11	-0.37	-0.01

laboratory test variables are presented in Table B3.5. For women, Arm Ergometer Peak Power was identified as a significant predictor variable, however, this was not a substantial relationship, accounting for only 10% of the variance in total time. For the young men, combined endurance grip and combined maximum grip were accepted in the analysis, accounting for 31% of the variance in total time. For men $\geq$ 35 years of age, pushups reliably predicted land evacuation performance ($R2_{=0.21}$). In table B3.6, blocked regression analyses are presented, with total time regressed on fitness parameters blocked according to the major fitness component. In compliance with the earlier regression analyses, none of the fitness components provided reliable relationships for young women. However, for both groups of men their strength-endurance component evidenced substantial relationship with total time, accounting for approximately 30% and 39% of the variance in the under and over 35 year groups, respectively.

Results of discriminant function analysis (conducted independently for groups) using a stepwise procedure in which both EXPRES and laboratory test variables were tested are presented in Table B3.7. Although the analysis could not be conducted with the group of men over 35, (see footnote) significant functions were obtained for each of young men and women. However, once again the discriminating variables were unique for the two groups. For young women, the maximum lifted in the ILM test to 152 cm was identified as the only significant discriminating variable, with the resultant function correctly classifying 66.7% of the cases. By comparison, the discriminant

Table B3.5

Stepwise Regression of Land Evacuation Total Time on Fitness Parameters by Sex and Age Level.

Variables in Equation	B	SE B	MultR	R^2	F	p
Women < 35 years						
Constant	1786.62	208.60				
Arm Ergometer Peak Power	-5.04	1.68	0.31	0.10	9.03	< .01
Men < 35 years						
Constant	1381.21	172.57				
Combined Endurance Grip	-1.14	0.41	0.51	0.26	18.49	< .001
Combined Maximum Grip	-3.99	1.96	0.56	0.31	11.89	< .001
Men ≥ 35 years						
Constant	982.30	86.30				
Pushup	-7.59	2.55	0.46	0.21	8.85	< .01

Table B3.6

Land Evacuation Task 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	0.048	1.42	>.05	0.048	1.42	>.05
Strength and Endurance	0.108	0.93	>.05	0.060	0.73	>.05
Aerobic Capacity	0.112	0.87	>.05	0.004	0.36	>.05
Lower Body Anaerobic	0.147	0.90	>.05	0.035	1.00	>.05
Upper Body Anaerobic	0.211	1.18	>.05	0.064	2.87	>.05
Men < 35 years						
Anthropometric	0.086	2.10	>.05	0.086	2.10	>.05
Strength and Endurance	0.389	3.81	<.001	0.303	4.24	<.001
Aerobic Capacity	0.390	3.43	<.001	0.002	0.18	>.05
Lower Body Anaerobic	0.438	3.12	<.001	0.048	1.59	>.05
Upper Body Anaerobic	0.441	2.67	<.01	0.003	0.16	>.05
Men ≥ 35 years						
Anthropometric	0.076	1.01	>.05	0.76	1.01	>.05
Strength and Endurance	0.402	2.58	<.05	0.387	3.08	<.05
Aerobic Capacity	0.603	4.00	<.01	0.140	10.25	<.01

Table B3.7

Discriminant Analysis and Classification Results by EXPRES and Other Laboratory Variables on Groups defined by Land Evacuation Task Pass Criteria of 20 Minutes.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	Performance %	Predicted Performance Correctly Classified n	Predicted Performance Correctly Classified %	Performance Incorrectly Classified n	Performance Incorrectly Classified %
Women < 35 years								
ILM Max to 152 cm	1.00	Pass	44	(58.7)	28	(63.6)	16	(36.4)
		Fail	31	(41.3)	22	(71.0)	9	(29.0)
		Total	75		50	(66.7)	28	(33.3)
Wilks' Lambda:	0.85							
Chi-Squared:	10.32							
Significance Level:	< .002							
Men < 35 years								
Combined Max Grip	0.97	Pass	61	(95.3)	61	(100.0)	0	(0.0)
Pushups	0.34	Fail	3	(4.7)	1	(33.3)	2	(66.7)
ILM Max to 183 cm	-0.43							
		Total	64		62	(96.9)	2	(3.1)
Wilk's Lambda:	0.82							
Chi-Squared:	12.25							
Significance Level:	< .01							

Notes: All men ≥ 35 years with complete data passed this task. Thus discriminant analysis could not be conducted.

function for men < 35 years was comprised of combined maximum grip, pushups, and maximum score on the ILM test to 183 cm; this function correctly classified 96.9% of these men. However, the apparent improvement in ability to discriminate male passers and failers over females may be artifactual in that only a very small percentage of the men (i.e., 4.7%) actually failed to complete the task in the criterion time.

B3.5 Interpretation

In direct contrast to the low high crawl and most other task performances the finding that subjects ≥ 35 years on average completed their evacuation task in less time than their younger counterparts was surprising. And all the more so considering that the majority of these subjects were either 'paced' (i.e., advised to slow down, according to their heart rate elevation) or stopped at least once during their carry (i.e., when heart rate response exceeded 90% of capacity). However, this result is not all that surprising given that combined max grip was identified as a significant discriminator for young men and that older men tend generally (c.f. CF EXPRES percentiles) to have higher max grip strength.

The initial CF directive on the land stretcher carry defined 20 minutes as the criterion time for passing. In the present study exactly 75% of the personnel completed the 1 km evacuation within this time limit (see figure A2); in MPFS I 71% of subjects bettered this criteria. Therefore, this time prerequisite was retained in the present MPFS phase as a reasonable passing standard (see Section A3.4). As well, the similar distribution of subjects achieving this criteria indicated that the protocol modifications made for MPFS II, particularly the addition of wheels and other small adjustments made to the land stretcher, probably did not alter the task substantially.

From Tables B3.3 and B3.4, again <u>total time</u> (for completion of the land evacuation in this case) was singled out as the optimal measure for evaluating subjects' performances; the other analyses correlating either split or incremental times with individual fitness scores did not result in higher or more consistent r-values. The singular exception to this trend was the evacuation performance times for men $\geq$ 35 years when correlated with aerobic capacity (as determined from their step test scores). Both their total time and all split-times during the 1 km evacuation produced highly negative ($p < .001$) r-values, however, this was not unexpected because these subjects were closely 'paced': that is, the higher each subject's aerobic capacity, the faster he was permitted to complete each phase of the evacuation. On the other hand, even for these subjects, neither the incremental results nor the calculated drop-off indices correlated well with aerobic capacity, lending further evidence that using derived performance variables as a means to evaluate performance on common military tasks are not any better - and may even be worse - than direct times, with total time in particular being the simplest and most straight forward to record.

In Table B3.8, the PASSERS within the individual groups (i.e., the 75% of subjects bettering the pass criterion) are profiled according to their EXPRES and laboratory

Table B3.8

Fifth Percentile Scores for Personnel Passing Land Evacuation Task by Sex and Age Level.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
EXPRES	(46)	(66)	(40)
Max Grip	45.7[d]	76.7[a,b,c,d]	74.6[d]
VO_2 Max	30.7	39.6	34.1[b]
Pushups	19.3	13.8[a]	12.0[b,c]
Situps	20.9	21.1	24.1
Queen's			
ILM max to 183 cm	15.00	31.7[a]	28.7
ILM max to 152 cm	18.8[a,d]	34.6	34.2
Flexed Arm Hang	-6.6	13.8[d]	16.2
Endurance Grip	22.0	34.1[b,c]	83.9
Arm Ergometer:			
Total Work	2952.1[d]	5245.2[d]	
Peak Power	98.4	174.8[d]	
% Fatigue	29.9[c,d]	31.6	
Leg Ergometer:			
Total Work	9490.5[d]	13427.4[d]	
Peak Power	381.2	532.4	
% Fatigue	24.7	27.4	

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 20 min.

scores. These values incorporated an almost identical subset of minimum EXPRES values as determined for the low high crawl in the preceding section (B2.5). Minimum situps were again almost identical for all groups, with the fewest number required of the female subjects in this case. And on the three remaining EXPRES test items, similar discrepancies appeared even though all these subjects 'passed' the land evacuation task.

i) The minimum grip requirement was again almost 50% less for women than men, while the latter's minimum standards was (again) independent of age, being almost identical for the men under and over 35 years.

ii) Minimum pushups were even lower for men than for women (compared to this MPFS subset determined for the low high crawl).

iii) Each group's minimum VO2 max value fell within 1 ml/kg/min of their minimal values determined for the low high crawl; in Section B2.5 it was argued these standards were influenced less by the performance requirements of the task and more by the expected physiological differences between subjects (i.e., gender differences and the effects of age).

Table B3.8 also summarizes results of earlier analyses indicating the relative importance of fitness variables to each of the groups in terms of evaluating task performance. Note that the variables identified as playing an important role are neither consistent across groups, nor within groups relative to the low high crawl task (compare with Table B2.6).

In Table B3.9, the efficacy of these minimim fitness

Table B3.9

Ability of Minimum Physical Fitness Standards (Based on All Tests) to Correctly Predict Performance on Land Stretcher Evacuation Task.

	Actual Task Performance	Predicted Performance			
		Correctly Classified		Incorrectly Classified	
	n	n	(%)	n	(%)
Women < 35 years					
Passed Land Evacuation	39	34 (true positives)		5 (false negatives)	
Failed Land Evacuation	30	10 (true negatives)		20 (false positives)	
Total	69	44	(63.8%)	25	(36.2%)
Men < 35 years					
Passed Land Evacuation	63	51 (true positives)		12 (false negatives)	
Failed Land Evacuation	3	1 (true negatives)		2 (false positives)	
Total	66	52	(78.8%)	14	(21.2%)
Men ≥ 35 years					
Passed Land Evacuation	40	33 (true positives)		7 (false negatives)	
Failed Land Evacuation	0	-		-	
Total	40	33	(82.5%)	7	(17.5%)

criteria determined across all tasks is tested, relative to actual stretcher carry performances. By group, on the basis of their fitness, 63.8% of women < 35 years were correctly classified as 'passers' while 78.8% of men < 35 years and 82.5% of males ≥ 35 years were correctly classified.

In contrast, of those predicted to fail according to the MPFS subset, by group only 33% of both women and men < 35 years were correctly classified (note: no male subjects ≥ 35 years failed the stretcher carry task). On the other hand, the number of false negative and positive classifications again proved highly variable ranging, respectively, from as low as 13% (for women < 35 years) to as high as 66% (for both the females and males > 35 years).

B3.6 Conclusions

From these data, again the conclusions to be drawn concerning task performance are limited by the lack of definitive statistical relationships between fitness and performance. Therefore, within these delimitations the following conclusions appear warranted:

1. By far, grip strength is the most important fitness variable in performance of the over land stretcher carry (Stevenson et al., 1985); secondarily, upper body strength-endurance is also an important fitness component involved in completion of this task.
2. Again, these data suggest that the most significant variables related to one's performance in the stretcher carry incorporate an unique set of fitness capacities

according to the subject's classification.

3. On the other hand, it was noteworthy how similar this MPFS subset proved to be in comparison with minimum EXPRESS values determined for the low high crawl (see section B2.5).

4. However, these MPFS variables (again) proved to be of limited value as discriminators of performance success on the stretcher carry task, while additional laboratory tests improved performance prediction immensely.

SECTION B4

SEA STRETCHER EVACUATION ANALYSIS

B4.1 Introduction

This 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 fire-fighting gear, carrying an 80 kg person lying on a stretcher a horizontal distance of 25 m, ascending one deck level and returning to the starting point; the time allotted for completion of this task was 10 minutes. While conducting this field test during MPFS I, two major deficiencies were encountered: foremost, the task could not be performed as defined by a single person; second, the only shipboard simulator on-land was located at the Forces fire-fighting school at CFB Halifax (where MPFS I was conducted). For the present study, therefore, these two task requirements were redressed by a redesign of the task, improving the data collection procedures, and the performance criteria.

B4.2 Task Rationale

Shipboard evacuation requires two persons working together, yet task performance (and any empirical evaluation thereof) can be limited by one, not necessarily both, of the persons carrying the stretcher. In the land evacuation task, this problem was resolved by two viable approaches: in MPFS I, by employing laboratory personnel to carry the 'other' end of the stretcher; in the present MPFS phase, by placing the stretcher's 'other' end on wheels (see Section B3). In each instance the subject of the experiment carried one-half the load, essentially converting this horizontal, 2-person task into a one-person carriage from the point of view of evaluating performance. However, when a vertical component is introduced into the task protocol, such as ascending and descending a steep flight of shipboard stairs, this method of evacuation immediately becomes a 2-person task with performance critically dependent upon the mutual and/or combined strength and skills of both parties. Prior to testing in MPFS I because of limited lead-time, these inherent problems in the task protocol as defined could not be addressed to any satisfactory degree.

For the present study a large metal structure was fabricated replicating a 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 both test sites, CFB Borden and Ottawa, to serve as the shipboard simulator. Built into the superstructure as well, the carriage phase of the stretcher, both up, then down the stairs, was redesigned as a <u>one-person task</u> with the front half of a specially built 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; yet considering the increased speed of performance and with personnel in full fire-fighting gear, this task could be performed with a much greater degree of subject supervision and safety.

Because of the time required to design and build the sea evacuation apparatus, pilot testing of the test-retest reliability of the procedure could not be conducted. However, it was felt that the modifications were likely to reduce testing error while maximizing subject safety.

In MPFS I, the physiological responses of both subjects performing the 2-person evacuation task were near-maximal (i.e. their heart rates and post-exercise blood lactate responses), in close agreement with the literature reported for load-carrying by a single subject working against gravity (Astrand & Rodahl, et al, 1977). Because of this non-discriminating response, as with the Land Stretcher Task, physiological variables were not recorded in the present MPFS phase, particularly since the task itself was simplified to a one-person simulation; heart rate was monitored in subjects ≥ 35 years for safety purposes.

B4.3 Task Protocol

A replication of the rear half of a Stoker stretcher was connected by a moveable apparatus to a flight of shipboard stairs. It was designed such that one subject alone could carry the stretcher during ascent and descent of the stairs. 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 fire-fighting gear, each participant was given opportunity to practice carrying the simulator, first unweighted, then partially weighted, until he/she felt both familiar and secure in moving up and down the flight of stairs. To further enhance personal safety a taut rope was readied at all times to catch the weight of the simulator; attached securely onto the top strut, the rope was controlled manually through a pulley system from the ground.

On the command "start", the participant 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 person then 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 participant 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 a 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 elapsed time splits: i) to the base of the stairs; ii) stairs ascent; iii) stairs descent; and iv) return to 'start' line.

B4.4 Results

Compared to MPFS I results, total time for completion of the modified one-person evacuation was well over 50% faster for all groups; this trend was also reflected in split-times (see Table B4.1). On average, males completed the task faster than females and only 3 males $\geq$ 35 years were forced to stop because of elevated heart rates. On the other hand, several females in both age classifications could not complete the task. The fastest

Table B4.1

Shipboard Evacuation Performance Scores by Sex and Age Level.

	Split Times (s)				Total Time (s)
	Start to Stairs	Up Stairs	Down Stairs	Stairs to Finish	
Women < 35 years (n=67)					
M	10.1	88.0	39.6	20.8	158.5
SD	2.9	86.6	22.6	7.4	103.74
(min-max)	(4-18)	(13-363)	(7-117)	(11-50)	(41-446)
Women ≥ 35 years (n=3)					
M	13.0	42.0	44.0	17.0	116.0
SD	4.6	43.3	27.6	3.6	65.6
(min-max)	(9-18)	(15-92)	(13-66)	(14-21)	(53-184)
Men < 35 years (n=69)					
M	6.9	17.7	15.2	11.5	51.3
SD	2.1	13.0	13.0	3.9	28.4
(min-max)	(4-15)	(6-112)	(2-82)	(6-29)	(21-229)
Men ≥ 35 years (n=38)					
M	9.9	19.3	28.8	16.9	74.9
SD	3.5	11.1	34.3	9.6	45.7
(min-max)	(4-21)	(8-55)	(5-133)	(6-62)	(26-227)

male completed the evacuation in 21 seconds, the fastest female in 41 seconds; again, considerable overlap between males and females were observed with several females achieving much faster times than the majority of males independent of age grouping. In fact, even the slowest person was able to complete the task finished in well under 10 minutes (i.e., 7.4 minutes). As expected, split-times were slowest as participants moved on the stairs; by comparison, over the horizontal portion of the course carrying from start line to stairs and back, times were fairly consistent, reflected by surprisingly low standard deviation values for all the groups (i.e., all under 10 seconds).

Tables B4.2a and b present correlation analyses results comparing EXPRES and laboratory test variables to performances times, specifically, total time to completion of the task in Table B4.2a, and split-times in Table B4.2b. For the two groups of men, under and over 35 years, all correlation coefficients were found to be low and non-significant. At 0.001 level of confidence accepted for these analyses $r>0.38$ was required and isolated coefficients approached this value, but these revealed no consistent pattern or frequency of occurrence. On the other hand, for women < 35 years, with regularity of occurrence r-values exceeded this level of confidence. Invariably, <u>negative</u> r-values relating performance times to fitness strength and power variables were recorded, principally to pushups, grip strength, the ILM lifts, and ergometer scores.

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 men $\geq$ 35 years only

Table B4.2a

Correlation Between Shipboard Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Total Time.

	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry			
Age	0.17	0.30	0.13
Height	-0.28	-0.29	-0.12
Weight	-0.32	0.04	-0.20
Muscular Strength and Endurance			
Situps	-0.05	-0.09	-0.20
Pushups	-0.24	-0.20	-0.38
Combined Grip	-0.43	-0.24	-0.11
Endurance Grip	-0.23	-0.19	-0.13
Flexed Arm Hang	-0.23	-0.20	-0.19
Max ILM to 183 cm	-0.24	-0.15	-0.32
Max ILM to 152 cm	-0.27	-0.13	-0.33
Aerobic Capacity			
Upper Body (Arm Ergometer)			
Total Work	-0.47	-0.19	
Peak Power	-0.46	-0.19	
Percent Drop-Off	0.04	0.31	
Lower Body (Leg Ergometer)			
Total Work	-0.56	-0.20	
Peak Power	-0.34	-0.10	
Percent Drop-Off	0.26	0.20	

Notes: 1) Correlation coefficients were not computed for ≥ 35 year-old women.

2) Coefficient of $r > |.38|$ required for significance at $p < .001$.

Table B4.2b

Correlation Between Shipboard Evacuation Performance Measures and Fitness Parameters by Sex and Age Level: Split-Times.

	Start to Stairs			Up Stairs		
	Women	Men		Women	Men	
	< 35 years	< 35 years	≥ 35 years	< 35 years	< 35 years	≥ 35 years
Anthropometry						
Age	0.14	0.31	-0.03	0.20	0.12	-0.08
Height	-0.07	-0.24	-0.03	-0.27	-0.27	-0.18
Weight	0.01	0.27	-0.44	-0.34	-0.12	-0.12
Muscular Strength and Endurance						
Situps	-0.06	-0.05	-0.37	-0.01	-0.03	-0.34
Pushups	-0.40	-0.02	-0.35	-0.21	-0.21	-0.34
Combined Grip	-0.26	-0.02	-0.04	-0.38	-0.28	-0.16
Endurance Grip	-0.15	0.03	-0.02	-0.15	-0.23	-0.05
Flexed Arm Hang	-0.40	-0.22	0.03	-0.17	-0.10	-0.22
Max ILM to 183 cm	-0.36	-0.24	-0.31	-0.21	-0.07	-0.12
Max ILM to 152 cm	-0.31	-0.16	-0.32	-0.23	-0.08	-0.23
Aerobic Capacity						
Step Test	-0.35	-0.40	-0.09	-0.17	-0.10	-0.17
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Total Work	-0.39	-0.18		-0.42	-0.19	
Peak Power	-0.39	-0.18		-0.42	-0.19	
Percent Drop-Off	0.09	0.23		-0.01	0.30	
Lower Body (Leg Ergometer)						
Total Work	-0.33	-0.08		-0.51	-0.23	
Peak Power	-0.23	-0.12		-0.29	-0.11	
Percent Drop-Off	-0.06	-0.05		0.27	0.23	

Notes: 1) For significance at $p < .001$, $r > |.38|$ is required.

Table B4.2b (cont)

	Down Stairs			Stairs to Finish		
	Women	Men		Women	Men	
	< 35 years	< 35 years	≥ 35 years	< 35 years	< 35 years	≥ 35 years
Anthropometry						
Age	-0.08	0.28	0.12	0.23	0.51	0.30
Height	-0.17	-0.22	-0.10	-0.32	-0.33	0.03
Weight	-0.15	0.11	-0.09	-0.11	0.19	-0.30
Muscular Strength and Endurance						
Situps	-0.15	-0.12	-0.02	-0.07	-0.14	-0.37
Pushups	-0.15	-0.20	-0.29	-0.27	-0.13	-0.26
Combined Grip	-0.35	-0.24	-0.05	-0.44	-0.06	-0.15
Endurance Grip	-0.34	-0.18	-0.11	-0.27	-0.06	-0.17
Flexed Arm Hang	-0.27	-0.23	-0.15	-0.30	-0.27	-0.11
Max ILM to 183 cm	-0.19	-0.17	-0.27	-0.26	-0.18	-0.34
Max ILM to 152 cm	-0.23	-0.13	-0.20	-0.32	-0.14	-0.48
Aerobic Capacity						
Step Test	-0.04	-0.16	-0.34	-0.24	-0.31	-0.01
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Total Work	-0.37	-0.17		-0.37	-0.15	
Peak Power	-0.37	-0.17		-0.37	-0.15	
Percent Drop-Off	0.23	0.28		-0.07	0.31	
Lower Body (Leg Ergometer)						
Total Work	-0.43	-0.17		-0.44	-0.11	
Peak Power	-0.35	-0.10		-0.35	-0.02	
Percent Drop-Off	0.11	0.14		0.10	0.20	

Table B4.3

Stepwise Regression Analyses of Shipboard Evacuation Total Time on Fitness Parameters by Sex and Age Level.

Variables in Equation	B	SE B	MultR	R^2	F	p
Women < 35 years						
Constant	438.96	53.22				
ILM Max to 152 cm	-4.83	2.28	0.48	0.23	25.21	<.001
Leg Ergometer Total Work	-0.013	0.006	0.51	0.26	15.04	<.001
Men < 35 years						
Constant	51.95	26.62				
Arm Ergometer % Fatigue	1.01	0.39	0.32	0.10	5.85	<.05
Combined Maximum Grip	-0.49	0.21	0.43	0.19	5.96	<.05
Men ≥ 35 years						
Constant	138.60	23.55				
Pushups	-1.92	0.70	0.43	0.19	7.62	<.01

pushups and no other fitness variables appeared in the regression equation; included for men < 35 years were arm ergometer fatigue and grip strength; however in both equations, only 19% of the variance in task performance was accounted for. On the other hand, for females < 35 years, stepwise regression highlighted two specific strength-power variables: ILM lift to 152 cm and leg ergometer power. Although these variables account for only 26% of the variance, the equation nevertheless proved significant at the 0.001 level.

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. For women < 35 years, in agreement with the stepwise analysis, 21% of the variance in task performance was accounted for by the strength-endurance component, and an additional 6% was accounted for by lower body anaerobic measures. However, these results also demonstrated reliable influences of anthropometric and aerobic parameters (accounting for 10% and 5% of the variance, respectively). For young men, the only reliable block of predictors was that of the anthropometric measures, ($R2$ =0.158). The remaining components accounted for less than 6% of the variance and were not significant. Similarly, for older men, none of the blocks were reliable predictors of performance (i.e., all were non-significant).

Discriminant function analyses (summarized in Table B4.5) showed a significant result only for women under 35. This is probably due to the fact that only 2 men, 1 in each of the two groups, failed to meet the criterion completion time; it should

Table B4.4

Shipboard Evacuation Task 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	0.102	3.19	<.05	0.102	3.19	<.05
Strength and Endurance	0.307	3.41	<.001	0.205	3.25	<.05
Aerobic Capacity	0.357	3.83	<.001	0.050	5.86	<.05
Lower Body Anaerobic	0.416	3.71	<.001	0.059	2.46	>.05
Upper Body Anaerobic	0.423	3.25	<.001	0.007	0.43	>.05
Men < 35 years						
Anthropometric	0.158	4.17	<.01	0.158	4.17	<.01
Strength and Endurance	0.213	1.62	<.05	0.055	0.60	>.05
Aerobic Capacity	0.213	1.45	>.05	0.001	0.01	>.05
Lower Body Anaerobic	0.263	1.43	>.05	0.051	1.29	>.05
Upper Body Anaerobic	0.269	1.25	>.05	0.007	0.24	>.05
Men ≥ 35 years						
Anthropometric	0.068	0.90	>.05	0.068	0.90	>.05
Strength and Endurance	0.261	1.06	>.05	0.193	1.12	>.05
Aerobic Capacity	0.323	1.26	>.05	0.063	2.68	>.05

Table B4.5

Discriminant Analysis and Classification Results by EXPRES and Other Laboratory Variables on Groups Defined by Sea Stretcher Evacuation Task Pass Criteria of 210 Seconds.

Discriminant Analysis Results		Classification Results						
Variables	Standardized Canonical Coefficients	Actual Status	Performance n	%	Predicted Performance Correctly Classified n	%	Incorrectly Classified n	%
Women < 35 years								
ILM Max to 152 cm	0.67	Pass	45	(59.2)	35	(77.8	10	(22.2)
Combined Max Grip	0.55	Fail	31	(40.8)	20	(64.5)	11	(35.5)
		Total	76		55	(72.4)	21	(27.6)
Wilks' Lambda:	0.81							
Chi-Squared:	15.52							
Significance Level:	< .001							
Men < 35 years								
Pushups	0.62	Pass	63	(98.4)	63	(100.0)	0	(0.0)
ILM Max to 183 cm	-0.85	Fail	1	(1.6)	0	(0.0)	1	(100.0)
Combined Max Grip	0.61							
		Total	64		63	(98.4)	1	(1.6)
Wilks' Lambda:	0.94							
Chi-Squared:	3.90							
Significance Level:	NS							
Men ≥ 35 years								
Pushups	1.00	Pass	36	(97.3)	36	(100.0)	0	(0.0)
		Fail	1	(2.7)	0	(0.0)	1	(100.0)
		Total	64		36	(97.3)	1	(2.7)
Wilks' Lambda:	0.97							
Chi-Squared:	1.19							
Significance Level:	NS							

also be noted that the older men who were stopped (i.e., because their heart rate respose exceeded 90% of maximal) were not included in this set of analyses. For women the stepwise procedure identified combined maximum grip and maximum score on the ILM test to 152 cm as reliable discriminating variables. The function, based on these two variables, correctly classified 72.4% of the women into passers and failers.

B4.5 Interpretation

The present shipboard evacuation was substantially altered on several counts from the task originally defined by the CF. Foremost, this protocol allowed assessment of an individual's own performance, thereby conforming to the template applied in evaluating all of other common military tasks. However, it must be questioned if the modified protocol still retained its intrinsic task specifications. From subjective observations it was judged to closely replicate the original task and, physically, each subject completed an identical amount of work in terms of lifting and carrying. However, the much faster split-times recorded throughout the evacuation as well as total time to completion would argue otherwise. (Stevenson et al, 1985). And certainly the criteria of 10 minutes 'total time' for passing versus failing had to be sharply reduced in order to evaluate performance success: the 25th percentile of these data distributions, the basis of the adopted 75% - 25% pass versus fail criteria, fell at 210 seconds (3.5 minutes) (see Figure A2.c). Subjectively, the present modified protocol was felt to be much safer, permitting more rigorous experimental control than the 2-person evacuation, where risk of both falling on the stairs and lower back injury appeared a greater possibility because of the precarious positions personnel had to assume at specific points through the 2-person task. Finally, from both the monetary perspective and in terms of convenience, the present protocol was judged vastly superior: the portable superstructure could be reassembled quickly and safely on-site negating relocation of our entire laboratory as well as CF subject personnel to CFB Halifax. For these latter reasons alone, it is recommended that this 1-person evacuation modification be adopted in future. From Tables B4.2a and b, for women < 35 years, the many significant r-values (22 in all, with several others approaching the .001 confidence level) relating various strength and power tests to task performance, indicate that superior fitness on specific tests enables subjects to complete defined phases of the sea evacuation more quickly. On the other hand, for both groups of men the majority of r-values were low, underscoring that this task was well within their physical strength-power capacities; however, consistent with the women's data, all but seven (of 57 coefficients) were recorded as negative values, at least suggestive of a fitness-performance relationship. Based upon these correlations, again, there was little evidence for including additional performance criteria <u>other than total time</u>. Regression analyses (see Tables B4.3 and B4.4) did little to clarify the exact nature of the relationship between fitness and performance. The observed relationships tended to be either statistically insignificant or not substantial enough to warrant inclusions. Discriminant function analysis did, however, provide some insight into women's performance, indicating upper body strength and lifting capacity (i.e., inferred by tests of grip and ILM lifting) as potential limiting factors. Subjectively, it was felt that technique and skill influenced performance variability to the greatest extent, particularly when the strength-power prerequisites demanded by the task itself were not well within the physical capacities of a subject; at a conservative estimate, up to half of the subjects fell into this category. At this point, however, this conclusion can only be speculative due to time restrictions during mass testing of CF personnel. Subjects were allowed sufficient practice to familiarize themselves with the task, but certainly not enough time to become expertly proficient; regretably, any test-retest repeatablility to examine the effects of learning were logistically impossible.

In Table B4.6, the PASSERS within the individual groups (i.e., bettering the pass criterion) are profiled according to their minimum EXPRES and laboratory scores (i.e., as indicated by fifth percentile of groups). This table also includes a summary of prior analyses, to highlight the relative importance of fitness variables to each of the groups in terms of evaluating task performance (see a-d superscripts explained in footnotes). Inconsistencies in influence of fitness variables on performance across groups were again noted. These minimum values also revealed trends similar to those observed earlier. Minimum situps were (almost) identical for all subjects regardless of gender or age level. With the remaining three EXPRES tests, familiar discrepancies again appeared even though all subjects,

Table B4.6

Fifth Percentile Scores for Personnel Passing Sea Stretcher Task by Sex and Age Level.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
EXPRES			
Max Grip	45.0 [a,b,d]	73.7 [c,d]	74.4 [d]
VO_2 Max	30.5	39.5	35.5
Pushups	18.3	13.6	14.4 [b,c]
Situps	21.4	21.1 [d]	20.7 [d]
Queen's			
ILM max to 183 cm	16.2 [d]	31.5	27.8
ILM max to 152 cm	19.10 [a,c,d]	34.3 [d]	33.6 [d]
Flexed Arm Hang	-5.9	14.0	16.4
Endurance Grip	14.9	31.6	75.8
Arm Ergometer:			
Total Work	2775.6 [b,d]	5254.2 [b,d]	
Peak Power	92.5 [b,d]	175.1 [b,d]	
% Fatigue	28.4	31.4 [c]	
Leg Ergometer:			
Total Work	9587.6 [b,c,d]	13388.7 [d]	
Peak Power	377.6 [d]	533.2	
% Fatigue	23.6	27.8	

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 20 min.

upon which this MPFS subset was based, 'passed' the sea evacuation task:

- minimum grip strength was substantially less for women than men, with the latters' standards being independent of age level;
- minimum pushups were substantially less for men than women because of EXPRES protocol requirements;
- and decrements in VO2 max, according to subjects' gender and age level, again appeared due to expected physiological (and not performance) disparities.

In Table B4.7, the efficacy of the overall minimum fitness criteria determined across al tasks is tested, relative to performance on the Sea Stretcher Evacuation Task. By group, on the basis of their fitness 59% pf women < 35 years were correctly classified as 'passers', while 78.8% of men < 35 and 82.5% of males ≥ 35 years were correctly classified. In contrast, of those predicted to fail according to this MPFS subset, bky group (respectively) 29.4% of females < 35 and 0% and 50% of the males were correctly classified. For the sea stretcher evacuation both the false negative and poitive classifications determined by this MPFS subset were quite constant but unfortunately at opposite ends of the prediction spectrum: i) the false negatives were surprisingly low, 18.2%, 20% and only 13.9% for the women and men < 35 and men ≥ 35 years, respectively; ii) on the other hand, the false positive classifications were consistently high (respectively) 70%, 100%, and 50%.

B4.6 Conclusions

From these data, again the conclusions to be drawn

Table B4.7

Ability of Minimum Physical Fitness Standards (Based on All Tests) To Predict Performance on Sea Stretcher Evacuation Task.

	Actual Task Performance	Predicted Performance			
		Correctly Classified		Incorrectly Classified	
	n	n	(%)	n	(%)
Women < 35 years					
Passed Sea Evacuation	44	36 (true positives)		8 (false negatives)	
Failed Sea Evacuation	34	10 (true negatives)		24 (false positives)	
Total	78	46	(59%)	32	(41%)
Men < 35 years					
Passed Sea Evacuation	65	52 (true positives)		13 (false negatives)	
Failed Sea Evacuation	1	0 (true negatives)		1 (false positives)	
Total	66	52	(78.8%)	14	(21.2%)
Men $\geq$ 35 years					
Passed Sea Evacuation	36	31 (true positives)		5 (false negatives)	
Failed Sea Evacuation	4	2 (true negatives)		2 (false positives)	
Total	40	33	(82.5%)	7	(17.5%)

concerning task performance are limited by the lack of definitive statistical relationships between fitness and performance. However, within these delimitations the following conclusions appear warranted:

1. The present, modified, 1-person task was judged an acceptable simulation of the tasked 2-person protocol, as originally defined by the CF, with several inherent advantages recommending adoption of this simulation for future testing.
2. Statistical analyses of performance were suggestive of a strength-power fitness dependency; this appeared to be particularly acute the lower a subject scored on specific strength and power tests.
3. This MPFS subset was again quite similar to the minimum EXPRESS values determined for both the low high crawl and over land stretcher carry (see section B2.5 and B3.5, respectively).
4. However, again MPFS based upon EXPRES variables of limited value as discriminators of performance success on the sea evacuation task, and additional laboratory tests improved performance prediction marginally (Stevenson et al, 1985).

SECTION B5

ENTRENCHMENT DIG TASK ANALYSES

SECTION B5

ENTRENCHMENT DIG TASK ANALYSES

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 foxhold (being) approximately 1.8 m long x 0.6 m wide". While conducting this field test as tasked during MPFS I, an insurmountable problem was encountered. At CFB Kingston where this phase was carried out in June, the clay-based soil had dried to rock-hard; in the strictest sense, therefore, this task as defined (i.e. "in soil of medium firmness") was never actually attempted by subjects, while the military's smaller "entrenching tool" had to be replaced by square-tipped spades with a much sharper digging edge so the feet and legs could assist to penetrate this soil. And while subjects gave their best efforts results were spurious: only 44% of male personnel completed the dig within 45 minutes, compared to our preliminary study conducted earlier in May 1985 on the same dig site where the fastest time overall (20 minutes) was recorded by one of the female subjects (Stevenson et al, 1985). Over the intervening year between MPFS I and II several 'remedies' were attempted all of which experienced little success while proving costly or too troublesome: the logistics of hauling 'normal soil' for up to fifteen simultaneous digs to test sites; the problems of compacting this soil 'to medium firmness' on site; the vagaries of weather at a given site affecting soil conditions; and so on. And further, while large open areas for digging could be made available at CFB Borden (for the present 1986 study), 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 the present MPFS phase in an effort to standardize testing protocol, particularly for consistent soil conditions, as well as to eliminate the unsightly mess left by such digs. One major outcome of the revised protocol was the profound reduction in dig time (see Table B5.1).

B5.2 Task Rationale

Earlier studies of military personnel (Passmore & Durnin, 1955) and coal miners (Morrissey et al., 1983) concluded that digging tasks require a significant expenditure of energy when performed over several hours. Expressed as an hourly expenditure, Passmore and Durnin (1955) examined work outputs for military personnel which ranged from 276 to 528 kcal/hr.; more recent estimation of coal-miners' energy expenditure was 408 kcal/hr. (Morrissey et al., 1983). This range of values was in good agreement with the working rates summarized by Astrand and Rodahl (1977). Chakraborty et al. (1974) determined that energy expenditure was sustained at 69% of their subjects' maximal aerobic capacity during prolonged digging; on the other hand, these investigators reported only a modest rise in blood lactate (34.8 mg%) post-dig. In the initial phase of MPFS, subjects'

Table B5.1

Entrenchment Dig Performance by Sex and Age Level.

	Total Time (s)	Rate of Shovelling* (no. / 15 s interval) First Minute	Middle Minute	Drop-off** (%)	Final Minute	Drop-off** (%)
Women < 35 years (n=85)						
M	510.6	10.8	7.3	-30.1	4.7	-54.0
SD	132.5	2.5	1.8	19.1	1.3	17.2
(min-max)	(273-993)	(3-18)	(3-11)	(-64-60)	(2-10)	(-78-47)
Women ≥ 35 years (n=8)						
M	590.3	8.9	6.4	-27.9	4.4	-48.6
SD	183.7	2.4	2.6	17.5	1.7	16.7
(min-max)	(364-944)	(4-12)	(4-11)	(-44- -6)	(3-7)	(-77- -29)
Men < 35 years (n=68)						
M	253.5	13.3	9.8	-25.9	5.9	-55.2
SD	51.3	2.6	1.9	13.8	1.8	14.6
(min-max)	(161-436)	(8-21)	(5-15)	(-59-9)	(2-11)	(-81-0)
Men ≥ 35 years (n=41)						
M	358.1	9.9	7.6	-22.0	4.8	-48.3
SD	113.1	2.5	2.4	19.8	2.1	24.8
(min-max)	(214-690)	(5-16)	(3-13)	(-61-32)	(2-15)	(-77-29)

* Number of shovelfulls emptied over a 15-second time period.

** % Drop-Off =

$$\frac{\text{Shovelling Rate Middle-/or Final Min. - Rate during 1st Min.}}{\text{Shovelling Rate Middle-or Final Min.}} \times 100$$

heart rate responses to digging their emplacements reflected a similar elevated rate of working throughout: for male personnel, 156 - 157 beats/minutes; for female personnel 157 - 160 beats/minutes (Stevenson et al., 1985). According to the literature, therefore, digging tasks, in the first instance, imply prolonged work where energy is expended at a constant, submaximal rate approaching 70% of maximal aerobic capacity, equivalent to 400 kcal/hr for males, slightly less (10-15%) for females. Second, since physiological parameters discriminate between subjects minimally, in the present phase of MPFS only subjects' performance was recorded (i.e., dig times), with heart rate monitoring being employed only with personnel ≥35 years in the interests of safety.

For MPFS II a box-hole dig was developed, literally a wooden box dimensioned 1.8 m in length x 0.6 m width x 0.45 m 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). By comparison with earlier studies, the box-hole dig produced a much shorter and, therefore, more intense task which was completed by the majority of personnel in under 10 minutes (refer to Table B5.1). So it must be questioned if, in fact, the protocol tested subjects' capacities for performing this type of prolonged work, the obvious intent of the emplacement dig as defined by the CF in their original tasking. Second, Queen's University Department of Ecology determined 'normal soil' to be essentially garden top-soil. During preliminary testing, however, beside the expense of purchasing this grade of soil, several additional shortcomings were encountered:

i) Its moisture content could not be well controlled: too much wetting produced heavier mud, not enough moisture much sandier soil, while a combination of these soil conditions was created when the water added did not disperse evenly.

ii) To compact top-soil to 'medium firmness' each time the box was emptied required substantial time and motorized tamping equipment.

iii) Conducted inside, after testing facilities and equipment had to be hosed-down if moistened top-soil was used.

Therefore, finely crushed rock was substituted in lieu of top-soil because it moderated these shortcomings. On the other hand, crushed rock proved difficult to compact to 'medium firmness' by any means, thereby making digging easier; for most subjects, therefore, only upper-body musculature was required for digging. These shortcomings notwithstanding, the box-hole dig provided a superior test than the entrenchment dig from the point of view of experimental control and subject safety. The confines of the box ensured that all subjects removed the identical volume of soil; this variable was judged to be a source of major error in field digging. The consistency of the crushed rock soil was always uniform, and of constant moisture content. During mass testing, many subjects were closely monitored one-at-a-time, as opposed to field digs where many entrenchments must proceed at one time; with the need to monitor subjects $\geq$ 35 years, the latter field format potentially placed these subjects at risk without closer supervision. And, in any case, outdoor field conditions vary daily with weather conditions, even when ideal top-soil conditions are 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 the limitations of the protocol. Pilot data, using 20 participants, evidenced a test-retest reliability coefficient of 0.99; thus, it was concluded that the primary goal in modification of the protocol, namely reduction of error variance through standardization of the protocol, was achieved.

B5.3 Task Protocol

The purpose of this task was to dig an entrenchment measuring 1.8 m x 0.6 m x 0.45 m 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 wetted by water. High sideboards were enclosed around these boxes, once the subject was inside and readied, 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. (Note:

using two parallel boxes in this manner saved time; the next subject simply emptied the second box, now full, and compacted upon completion of the earlier test, back into the first box and so on back-and-forth). 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 completed only when the laboratory personnel, perched on a high seat 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 shovelling (the number of full shovelfuls were counted and recorded every 15 seconds throughout the dig).

B5.4 Results

In Table B5.1, subjects' times for completion of the entrenchment dig are presented, along with their shovelling rates at fixed intervals through the dig: during the first, middle, and last minutes. On average, male personnel < 35 years completed the dig in 4 min: 14 sec, while men $\geq$ 35 years, all of whom had to be either paced or stopped (completely) during their dig, required just over a minute longer 5 min: 36 sec. By comparison, on average, female personnel < 35 years completed the dig in 8 min: 30 sec while the eight women ≥ 35 years completed in 9 min: 50 sec. The fastest times for the dig were 2 min: 41 sec for a male < 35 years and less than a minute longer (3 min: 32 sec) for one female < 35 years. And while several personnel ≥ 35 years appeared capable of matching these 'best times', they were prevented from working at such an intense rate in order to do so. As noted for all tasks, again, considerable overlap was observed between the fastest times recorded by females and the majority of the males scores. Finally, throughout the dig, shovelling rates progressively decreased, with the younger groups < 35 years experiencing the greater drop-offs because they began at faster rates than the ≥ 35 year old subjects. However, by the end of the dig, on average all subjects had slowed to approximately 50% of their initial rates of shovelling.

Tables B5.2a, b, c present results of correlation analyses comparing subjects' EXPRES and laboratory test variables in relation to performance times, specifically, total times for the dig (Table B5.2a), the shovelling rates through their digs (Table B5.2b), and the precent drop-off of these digging rates (Table B5.2c). In Table B5.2a, all but three (of 36 coefficients) appeared as negative values, again strongly suggestive of a fitness-performance relationship, only on this task the pattern was much clearer. For the women < 35 years, seven (of 14) coefficients were significant and for the men < 35 three (of 14) r-values ($p<.001$), with the common test items being their ILM lifts and anaerobic powers: the higher these test scores the

Table B5.2a

Correletions Between Entrenchment Dig Total Time and Fitness Parameters by Sex and Age Level.

	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry			
Age	0.12	0.22	0.22
Height	-0.13	-0.26	0.10
Weight	-0.17	-0.15	-0.12
Muscular Strength and Endurance			
Situps	-0.23	0.02	-0.12
Pushups	-0.40	-0.03	-0.33
Combined Max Grip	-0.25	-0.32	-0.17
Endurance Grip	-0.36	-0.21	-0.20
Flexed Arm Hang	-0.34	-0.14	-0.26
Max ILM to 183 cm	-0.28	-0.33	-0.18
Max ILM to 152 cm	-0.37	-0.39	-0.24
Aerobic Capacity			
Step Test	-0.17	-0.24	-0.40
Anaerobic Capacity			
Upper Body (Arm Ergometer)			
Total Work	-0.48	-0.25	
Peak Power	-0.48	-0.25	
Percent Drop-Off	-0.06	0.25	
Lower Body (Leg Ergometer)			
Total Work	-0.48	-0.43	
Peak Power	-0.39	-0.30	
Percent Drop-Off	0.03	0.17	

Notes: Coefficients of $r > .38$ for significance at $p < .001$

Table B5.2b

Correlations Between Entrenchment Dig Shovelling Rate and Fitness Parameters by Sex and Age Level.

	Average Number of Shovel per 15 s Interval								
	First Minute			Middle Minute			Last Minute		
	Women < 35 years	Men < 35 years	Men ≥ 35 years	Women < 35 years	Men < 35 years	Men ≥ 35 years	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry									
Age	-0.27	-0.16	0.04	-0.07	-0.30	-0.18	0.13	-0.19	-0.11
Height	0.001	0.06	0.27	0.11	0.19	-0.001	-0.01	0.06	0.02
Weight	-0.02	-0.01	-0.05	0.19	0.13	-0.10	-0.05	0.01	0.10
Muscular Strength and Endurance									
Situps	0.18	0.15	0.06	0.15	0.01	0.17	0.15	0.02	-0.08
Pushups	0.27	0.25	0.08	0.21	0.17	0.37	0.24	-0.01	-0.01
Combined Max Grip	0.01	-0.02	0.04	0.13	0.19	0.05	-0.17	-0.07	0.04
Endurance Grip	0.01	0.14	0.25	0.31	0.21	0.28	0.11	-0.09	0.46
Flexed Arm Hang	0.22	0.34	0.13	0.24	0.13	0.29	0.18	0.14	0.03
Max ILM to 183 cm	0.08	0.19	0.11	0.14	0.33	0.15	0.12	0.26	0.14
Max ILM to 152 cm	0.11	0.16	0.13	0.23	0.34	0.19	0.10	0.30	0.07
Aerobic Capacity									
Step Test	0.26	0.13	0.21	0.15	0.21	0.53	0.06	-0.02	0.14
Anaerobic Capacity									
Upper Body (Arm Ergometer)									
Total Work	0.18	0.02		0.41	0.20		0.17	-0.08	
Peak Power	0.18	0.02		0.41	0.20		0.17	-0.08	
Percent Drop-Off	-0.19	-0.14		-0.14	-0.25		-0.04	-0.05	
Lower Body (Leg Ergometer)									
Total Work	0.26	0.07		0.38	0.33		0.11	0.09	
Peak Power	0.25	-0.04		0.33	0.15		0.07	0.05	
Percent Drop-Off	0.01	-0.19		-0.04	-0.26		-0.08	0.08	

Notes: $r > 0.38$ required for significance at $p < .001$.

Table B5.2c

Correletions Between Entrenchment Dig Drop-Off and Fitness Parameters by Sex and Age Level.

	Drop-off in Shovelling Rate					
	Middle Minute			Final Minute		
	Women < 35 years	Men < 35 years	Men ≥ 35 years	Women < 35 years	Men < 35 years	Men ≥ 35 years
Anthropometry						
Age	0.30	-0.08	-0.24	0.41	-0.05	-0.12
Height	0.04	0.13	-0.29	-0.04	0.02	-0.15
Weight	0.19	0.12	-0.09	-0.04	0.03	0.05
Muscular Strength and Endurance						
Situps	-0.01	-0.14	0.19	-0.02	-0.06	-0.08
Pushups	-0.14	-0.05	0.43	-0.12	-0.13	-0.06
Combined Max Grip	0.07	0.22	0.03	-0.18	-0.06	0.03
Endurance Grip	0.34	0.09	0.04	0.13	-0.16	0.13
Flexed Arm Hang	-0.03	-0.21	0.27	-0.08	-0.07	0.03
Max ILM to 183 cm	0.04	0.15	0.09	0.05	0.13	0.06
Max ILM to 152 cm	0.04	0.19	0.11	-0.03	0.20	-0.05
Aerobic Capacity						
Step Test	-0.15	0.07	0.44	-0.19	-0.11	0.04
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Total Work	0.17	0.18		-0.06	-0.13	
Peak Power	0.17	0.18		-0.06	-0.13	
Percent Drop-Off	0.06	-0.13		0.16	0.02	
Lower Body (Leg Ergometer)						
Total Work	0.06	0.26		-0.18	0.04	
Peak Power	-0.01	0.18		-0.22	0.05	
Percent Drop-Off	-0.07	-0.11		-0.07	0.17	

Notes: $r > 0.38$ required for significance at $p < .001$.

faster individual subjects completed their digs. In contrast, for men ≥ 35 years who were 'paced', aerobic capacity (again) produced the only significant r-values for the group. By comparison, in Table B5.2b only six (of over 100) r-values were significant, in B5.2c only two (of 72) were significant, and over three-quarters of these correlation coefficients appeared as positive values. Therefore, as with other statistical analyses throughout section B, the latter derived variables (i.e., shovelling rates, drop-off indicies, etc.) merely added unnecessary complexity to the measurement of performance without providing superior criteria for its assessment.

Stepwise regression analyses of entrenchment dig total time on fitness parameters are summarized in Table B5.3. For young women, two variables were identified, leg ergometer total work and flexed arm hang, providing an R^2 of 0.29 (p<.001). Similarly, for young men, arm ergometer total work and predicted VO_2 max were identified as significant predictor variables, accounting for 29% of the variance in entrenchment dig total time. Regression analysis failed to identify any reliable relationships for men ≥ 35 years.

In Table B5.4 results of regressing total time on EXPRES and laboratory scores blocked for fitness components are presented. For young women and men, the only significant block of variables is that of strength-endurance, evidencing changes in R2 of 0.251 and 0.239, respectively, for each group. The reliable predictor for older men was that of aerobic capacity, accounting for 12% of the variance in Dig total time (however, as noted in each section through section B, the fact that these subjects were

Table B5.3

Stepwise Regression of Entrenchment Dig Total Time on Fitness Parameters by Sex and Age Level.

Variables in Equation	B	SE B	MultR	R^2	F	p
Women < 35 years						
Constant	906.15	74.27				
Leg Ergometer Total Work	-0.03	0.006	0.46	0.21	23.08	<.001
Flexed Arm Hang	-2.85	0.92	0.54	0.29	17.52	<.001
Men < 35 years						
Constant	618.17	77.90				
Arm Ergometer Total Work	-0.02	0.007	0.45	0.21	13.79	<.001
Predicted VO2 Max	-2.87	1.21	0.54	0.29	10.44	<.001

Notes: For Men ≥ 35 years, no variables appeared in the regression equation.

Table B5.4

Entrenchment Dig Task 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						
Anthropo metric	0.042	1.22	>.05	0.042	1.22	>.05
Strength and Endurance	0.293	3.19	<.01	0.251	3.90	<.001
Aerobic Capacity	0.293	2.86	<.01	0.000	0.00	>.05
Lower Body Anaerobic	0.335	2.63	<.01	0.042	1.55	>.05
Upper Body Anaerobic	0.356	1.17	>.05	0.021	1.17	>.05
Men < 35 years						
Anthropo metric	0.118	2.98	<.05	0.118	2.98	<.05
Strength and Endurance	0.357	3.33	<.01	0.239	3.19	<.01
Aerobic Capacity	0.378	3.26	<.01	0.021	1.95	>.05
Lower Body Anaerobic	0.437	3.10	<.001	0.059	1.95	>.05
Upper Body Anaerobic	0.444	2.69	<.01	0.007	0.35	>.05
Men ≥ 35 years						
Anthropo metric	0.074	0.99	>.05	0.074	0.99	>.05
Strength and Endurance	0.268	1.10	>.05	0.194	1.13	>.05
Aerobic Capacity	0.391	1.69	>.05	0.123	5.88	<.05

'paced' accounted for this consistent finding).

Discriminant function analyses (using a stepwise procedure) also identified reliable discrimating variables for young women and men $\geq$ 35 years (Table B5.5). The function determined for young women, including the variables of flexed arm hang, predicted $VO2^{max}$ and ILM lift to 152 cm, correctly classified 61.3% of these subjects. For the latter group, predicted $VO_{2\ max}$ and combined maximum grip were accepted in the analysis; the resultant function correctly classified 95% of the men $\geq$ 35 years.

B5.5 Interpretation

Compared to entrenchment dig times recorded in MPFS I - during both the preliminary study as well as mass testing in June 1985, (Stevenson et al, 1985) - the box-hole dig times in the present MPFS phase were profoundly reduced: from 20 minutes down to 3-4 minutes for the fastest subjects comparing MPFS I versus II, on average from 51 and 92.8 minutes (for the male and female groups, respectively) to under 15 minutes in the present study for all but a few personnel $\geq$ 35 years who were stopped or forced to rest during their digs because of an elevated heart rate response > 90% of capacity. Subjectively comparing MPFS I versus II, digging technique was substantially altered. Outdoors, digging through very solid, virgin soil, the lower-body was used much more while the box-hole technique employed the shoulders and back almost exclusively. The intensity of working was significantly increased during the box-hole test as well, subjects realizing that this task did not require the better part of one hour to complete and, therefore, relaxed their self-

Table B5.5

Discriminant Analysis and Classification Results by EXPRES and Other Laboratory Variables on Groups Defined by Entrenchment Dig Task Pass Criteria of 510 Seconds.

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								
ILM Max to 152 cm	0.64	Pass	45	(60.0)	34	(75.6)	11	(24.4)
Flexed Arm Hang	0.72	Fail	30	(40.0)	12	(40.0)	18	(60.0)
VO2 Max	-0.42							
		Total	75		46	(61.3)	29	(38.7)
Wilks' Lambda:	0.87							
Chi-Squared:	8.50							
Significance Level:	< .05							

Men < 35 years

All men with complete data passed this task. Thus discriminant analysis could not be conducted.

Variables	Standardized Canonical Coefficients	Actual Status	Performance n	Performance %	Correctly Classified n	Correctly Classified %	Incorrectly Classified n	Incorrectly Classified %
Men ≥ 35 years								
VO2 Max	0.90	Pass	36	(90.0)	36	(100.0)	0	(0.0)
Combined Max Grip	0.73	Fail	4	(10.0)	2	(50.0)	2	(50.0)
		Total	40		38	95.0	2	5.0
Wilks' Lambda:	0.75							
Chi-Squared:	10.79							
Significance Level:	< .005							

governor which 'paced' their digging rate at two-thirds capacity throughout the field dig (Morrissey et al., 1983; Stevenson et al., 1985). On the other hand, the present box-hole protocol possessed several inherent advantages (see Task Rationale, B5.2), and from results appeared to produce a much purer digging task; by comparison, results from the entrenchment dig outdoors were interpreted as almost meaningless in our final MPFS I report (Stevenson et al., 1985). Therefore, Since the dig as originally tasked required prolonged work, an appropriate future modification would be to increase the box dimensions so that digging times increased in accordance with the intended objectives of the task. In turn, this would satisfy both its physical demands as well as the intent of the emplacement dig as tasked by the CF in their initial definition.

As discussed throughout section B, the criteria for 'passing' versus 'failing' had to be revised for this task as well (see Interpretation section), with the 45-minute criterion invoked for MPFS I being drastically reduced. Employing total time as the best criterion for successful completion of the task, the 25th percentile for the present data (applying the adopted 75% - 25% pass vs. fail criteria, see Section A3.4) fell at 510 seconds. In Table B5.6, for the PASSERS within the individual groups achieving this criterion, the 5th percentile values (see Section A3.5) created yet another very similar subset of MPFS test scores. The minimum situps requirements were (again) very similar for all subjects independent of gender and age, while the familiar discrepancies appeared between the remaining three EXPRES test items - even though all subjects from whom these MPFS

Table B5.6

Fifth Percentile Scores for Personnel Passing Entrenchment Dig Task by Sex and Age Level.

Variables	Women < 35 years	Men < 35 years	Men ≥ 35 years
Max Grip	42.8[d]	73.5	76.3[a,d]
VO2 MAX	29.7a	39.5[c]	35.3[a,b]
Pushups	19.3[b,d]	13.4	14.1[d]
Situps	18.8[c]	21.2	23.7
Queen's			
ILM max to 183 cm	14.7	31.6	28.0
ILM max to 152 cm	18.2[a]	34.4[b]	34.1
Flexed Arm Hang	-5.8[a,c,d]	14.1	17.8[d]
Endurance Grip	10.9	31.3	88.1
Arm Ergometer:			
Total Work	2792.4[b,d]	5259.6[c]	
Peak Power	93.1[b,d]	175.3	
% Fatigue	30.1	31.3	
Leg Ergometer:			
Total Work	8997.1[b,c]	13415.0[b]	
Peak Power	374.6[b]	535.3	
% Fatigue	25.5	27.8	

a Variable identified on the basis of discriminant analysis as a reliable discriminating variable between passing and failing groups.

b Reliable relationship between EXPRES and Task variable as indicated by simple correlation coefficient.

c Reliable relationship between EXPRES and Task variable as indicated by regression analyses.

d Main effect of pass-fail status in predicted direction indicated by ANOVA.

NOTE: Pass level is set at 510 s.

values were calculated 'passed' the dig task:

- pushup minimums were (again) quite similar for all groups;
- the minimum grip for the women (again) was 50% less;
- and VO_2 max (again) related more to physiological differences (i.e., gender, age, etc.) than to any aspect of task performance.

And once again, as illustrated in Table B5.6, the relative importance of each of the fitness variables presented a unique pattern for each group (see a-d superscripting), with the power-endurance being the main factors for both women < 35 years and men $\geq$ 35 years.

In Table B5.7, the efficacy of the minimum fitness criteria determined across all tasks, is tested relative to subjects' entrenchment dig performances. By group, on the basis of their fitness, 60.5% of women < 35 years were correctly classified as 'passers' while 80.3% of men < 35 and 82.5% of males $\geq$ 35 years were correctly classified. In contrast, of those predicted to fail according to this MPFS subset, by group only 29% of women < 35 and 50% of men $\geq$ 35 years were correctly classified (note: no male subjects $\geq$ 35 years failed the entrenchment dig task). On the other hand, the number of false negative and positive classifications (again) proved highly variable varying, respectively, from as low as 13.9% (for men $\geq$ 35 years) to as high as 71% (for women < 35 years).

B5.6 Conclusions

From these data the conclusions to be drawn concerning task performance are restricted by the lack of definitive statistical

Table B5.7

Ability of Minimum Physical Fitness Standards (Based on All Tests) to Predict Performance on Entrenchment Dig Task.

	Actual Task Performance	Predicted Performance			
		Correctly Classified		Incorrectly Classified	
	n	n	(%)	n	(%)
Women < 35 years					
Pass	45	37 (true positives)		8 (false negatives)	
Fail	31	9 (true negatives)		22 (false positives)	
Total	76	46	(60.5%)	30	(39.5%)
Men < 35 years					
Pass	66	53 (true positives)		13 (false negatives)	
Fail	0	0		0	
Total	66	53	(80.3%)	13	(19.7%)
Men ≥ 35 years					
Pass	36	31 (true positives)		5 (false negatives)	
Fail	4	2 (true negatives)		2 (false positives)	
Total	40	33	(82.5%)	7	(17.5%)

relationships between fitness and task performance, particularly for men $<$ 35 years. Therfore, within these delimitations the following conclusions appear warranted:

1. Muscular power and endurance are the most important fitness variables in performance of the entrenchment dig, particularly for women $<$ 35 years and men $\geq$ 35 years; on the other hand, the physical requirements of this task appeared to be wel within the capacities of the younger groups of men.
2. Further, these data again strongly suggest that the entrenchment dig requires an unique set of fitness capacities, according to the subject's classification.
3. On the other hand, the MPFS subset determined for this task was quite similar to minimum EXPRESS values determined for the other military tasks studied (see Interpretation section in B).
4. However, those MPFS variables also proved to be of limited value as discriminators of performance success on the entrenchment dig, while additional laboratory tests improved performance prediction minimally.

SECTION B6

SAND BAG CARRY TASK ANALYSIS

SECTION B6

SAND BAG CARRY TASK ANALYSIS

B6.1 Introduction

A sand bag carrying task was not an entirely new protocol instituted for the present phase of MPFS; in fact, Lift-and-Carry was one of the tasks studied in detail during preliminary testing conducted prior to MPFS I (see Appendix D, Stevenson et al, 1985). As defined by the CF initially, this task allowed 10 minutes for,

> "the soldiers to lift and carry a 50 lb bag of sand for 50 m . . . . set down the bag . . . . move back to the starting line . . . . repeating the procedure until 8 bags are moved."

During our preliminary work in 1985, on average the male personnel completed this task in 5.3 minutes, the female personnel in 7.4 minutes, with only one subject just marginally failing to achieve the 10-minute time criterion. Even though these subjects' heart rate response upon completing the task were near-maximal (on that occasion averaging 174 beats/per minute for both male and female groups), this task as defined was selected out of the 1985 MPFS battery because, with such a high success ratio and uniform physiological response, its potential to discriminate between subjects appeared limited.

For the present MPFS II phase, the task was modified slightly and renamed the Sand Bag Carry. Although the 10 minute time limit was retained, the task objective became the total number of 20 kg sand bags that could be carried within this time period. When extended for 10 minutes this modified version produced an extremely gruelling task for subjects to complete (see Appendix D). Therefore, considering the constraints imposed upon personnel $\geq$ 35 years, these subjects could not have performed this task maximally and for this reason the Sand Bag Carry was conducted only at CFB Borden, where all subjects were < 35 years.

B6.2 Task Rationale

In effect, this new protocol retained the intent of the original task, that of simulating an emergency situation where sand bags are 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 this way it was hoped the modified protocol would discriminate between personnel. In comparison to results from the preliminary testing in 1985 where a standard number of sand bags were handled (i.e., 8 bags only), several men and women doubled that number of bags under the present protocol(see Table B6.1), thus presenting several problems. Optimally, horizontal load carrying up to 35% of body weight can be performed for prolonged periods employing the upperbody 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 other subjects attempted, the rate of working actually declines proportionately as the physiological cost creeps above that which can be sustained for lengthy periods (Snook et al,

Table B6.1

Sandbag Carry Performance Scores by Sex.[1]

	Time to Complete Full Cycle: 1st Sandbag Seconds	8th Sandbag Sec	8th Sandbag % Drop-off	Final Sandbag Sec	Final Sandbag % Drop-off	Total No. Moved	Average Speed (m/s)
Women < 35 years (n=18)							
M	39.6	49.6	-29.0	47.3	-22.4	13.1	2.17
SD	8.4	9.1	30.8	8.7	24.4	1.4	0.23
(min-max)	(27-62)	(39-78)	(-16 to 117)	(36-65)	(-18 to 75)	(10-15)	
Men < 35 years (n=48)							
M	30.2	36.3	-22.1	35.2	-18.0	17.1	2.86
SD	5.0	4.2	17.5	6.8	23.3	1.8	0.30
(min-max)	(20-41)	(30-51)	(-10 to 80)	(22-52)	(-32 to 86)	(13-21)	

Notes:

1 The Sandbag Carry Task was conducted at CFB Borden only, thus there are no data for subjects $\geq$ 35 years of age.

2 Percentage Drop-off is calculated relative to time to complete cycle (i.e., pick up sandbag, carry it 50 m and return) for first sand bag.

$$\% \text{ Drop-off} = \frac{\text{time 1st sandbag} - \text{time 8th/or final sandbag}}{\text{time 1st sandbag}} \times 100$$

1970; Snook & Ciricello, 1974). Moreover, there are interactions with elevated environmental temperatures and humidity, as experienced at CFB Borden in June, that can have a further detrimental effect upon this balance of submaximal loading and physiological cost (Snook & Ciricello, 1974). On the other hand, there does not appear to be a single, 'best method' for load carrying with the upperbody, as long as some basic principles of carriage are observed (Legg & Mahanty, 1985). Foremost, the load should be located as close to the trunk as possible; that is, as the load's centre of gravity is located closer to the body's centre of gravity both antero-posterior and lateral stability are improved (Perrynowsi 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, in the present study, to optimize conditions for carrying the 20 kg bags as quickly as possible, various methods for lifting the sand bags, then carriage through the 50 m course to set-down, were taught to subjects (see Appendix C for details). In essence, subjects were permitted, within these delimitations, to employ both self-selected pick up and carriage techniques; these were usually determined individually after several practice trials conducted much earlier. Pilot testing with this task, employing 23 participants, evidenced a test-retest reliability coefficient of r=0.96.

B6.3 Task Protocol

The sand bag carry simulated an emergency situation where 20 kg bags full of earth 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 sand bags (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 sand bag carry simultaneously: one subject starting from one end of the course moving those sand bags 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 sand bags at the end of the 10-minute test period would be no more than 2 or 3 sand bags; 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 sand bags in the end piles as the physically superior personnel lapped the second subject, on some occasions several times particularly nearing the end of the test period. In addition, at each end of the course a laboratory test personnel monitored the progress of the subject who started from that end, recording:

i) total number of sand bags moved during the 10-minute test period;

ii) at the 10-minute mark, according to the plastic cones spaced 10 m apart, the exact distance through the course that the subject had progressed (carrying this last sand bag);

iii) split-times throughout the 10-minute test period, each time the subject returned to pick up the next sand bag.

On the command "start", as quickly as possible each subject lifted the first sand bag and carried it along the tract 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 sand bag; 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 test personnel recorded the subjects' progress at that point through the course, to the nearest 10-metre distance.

Prior to testing, personnel were given detailed instruction on correct technique of lifting a sand bag, for 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 warmup (see Appendix F for details).

B6.4 Results

In Table B6.1, sand bag performances for the CFB Borden personnel are presented. On average, males < 35 years moved just over 17 sand bags while their female counterparts, much fewer in number, moved just over 13 bags in the 10-minute test period. As observed at every testing station, there was considerable overlap between the female personnel moving the greatest number of sand bags and almost half the male subjects. Throughout, the men

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maintained a slightly faster speed than the women, 2.9 m/s versus 2.2 m/s (5.1 vs. 4.4 m.p.h.) respectively, by completing each lap at a faster pace (i.e., on average, a constant difference of 9 - 14 seconds faster) even when both groups of subjects began to tire through the 10-min test period.

Tables B6.2 a-c present correlation analyses of EXPRES and laboratory test variables in relation to performance measures: specifically, the total number of bags carried, Table B6.2a; individual lap times, Table B6.2b; and the percentage drop-off in these lap times, Table B6.2c. For women < 35 years, in Table B6.2a eight (of 14) coefficients relating the total bags moved to their muscular endurance, strength and power test scores were found to be significant ($p < 0.001$) the two highest r-values associated with their ILM lift to 183 cm and leg power; similarly in Table B6.2b, several more significant r-values appeared, most notably relating their max ILM lifts and ergometer scores to various lap times. By comparison, for the men < 35 years, in both Tables B6.2a and B2.6b only one (of 64) r-values was significant. In Table B6.2c relating fitness to task fatigue (as determined by % drop-off), only two r-values were significant, and overall (i.e., through the three B6.2 tables) aerobic capacity consistently provided the lowest statistical relationship: four (of 12) coefficients appearing as negative values, with five (of the 8 positive r's) approaching zero.

Results of the stepwise regression analyses of the total number of sandbags moved on EXPRES and laboratory test variables are shown in Table B6.3. For both groups of subjects, unfortunately, these analyses evidenced few reliable predictors of

Table B6.2a

Correlations Between Sandbag Carry Performance Measures and Fitness Parameters by Sex: Total Number of Bags Carried.

	Women < 35 years	Men < 35 years
Anthropometry		
Age	0.49	-0.12
Height	0.17	0.02
Weight	0.36	-0.06
Muscular Strength and Endurance		
Situps	0.42	0.28
Pushups	0.26	0.22
Combined Grip	0.34	0.20
Endurance Grip	0.46	0.49
Flexed Arm Hang	0.43	0.32
Max ILM to 152 cm	0.39	0.11
Max ILM to 183 cm	0.49	0.13
Aerobic Capacity		
Step Test	-0.09	0.28
Anaerobic Capacity		
Upper Body (Arm Ergometer)		
Total Work	0.44	0.08
Peak Power	0.44	0.08
Percent Drop Off	-0.34	-0.29
Lower Body (Leg Ergometer)		
Total Work	0.56	0.14
Peak Power	0.29	0.03
Percent Drop Off	-0.35	-0.27

Notes: 1) subjects $\geq$ 35 years did not complete the sandbag carry.

2) Coefficients of $r \geq .38$ required for significance $p < 0.001$.

Table B6.2b

Correlations Between Sandbag Carry Performance Measures and Fitness Parameters by Sex: Lap Times.

	Time to Complete Cycle					
	First Sandbag		Eighth Sandbag		Final Sandbag	
	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years
Anthropometry						
Age	-0.10	0.02	-0.41	0.23	-0.37	-0.11
Height	0.11	-0.06	-0.33	-0.01	0.03	-0.03
Weight	-0.29	-0.11	-0.32	0.22	-0.27	-0.01
Muscular Strength and Endurance						
Situps	-0.43	-0.25	-0.29	-0.16	-0.35	-0.26
Pushups	-0.39	-0.02	-0.08	-0.14	-0.12	-0.18
Combined Grip	-0.16	-0.19	-0.38	-0.10	-0.43	-0.10
Endurance Grip	-0.02	-0.17	-0.47	-0.34	-0.50	-0.28
Flexed Arm Hang	-0.21	-0.02	-0.36	-0.29	-0.30	-0.07
Max ILM to 152 cm	-0.50	-0.05	-0.32	0.01	-0.22	-0.17
Max ILM to 183 cm	-0.53	-0.06	-0.40	0.03	-0.32	-0.23
Aerobic Capacity						
Step Test	0.04	-0.32	0.09	-0.11	0.13	-0.25
Anaerobic Capacity						
Upper Body (Arm Ergometer)						
Total Work	-0.39	-0.17	-0.45	-0.01	-0.32	0.17
Peak Power	-0.39	-0.17	-0.45	-0.01	-0.33	0.17
Percent Drop Off	0.32	0.10	0.31	0.37	0.17	0.18
Lower Body (Leg Ergometer)						
Total Work	-0.43	-0.04	-0.49	-0.03	-0.44	-0.21
Peak Power	-0.10	0.02	-0.24	0.09	-0.19	-0.10
Percent Drop Off	0.49	0.26	0.37	0.32	0.26	0.19

Notes: $r \geq .38$ required for significance at $p < 0.001$.

Table B6.2c

Correlations Between Sandbag Carry Performance Measures and Fitness Parameters by Sex: Drop-off in Lap Times.

	Drop-off in Time to Complete Cycle			
	Eighth Sandbag		Final Sandbag	
	Women < 35 years	Men < 35 years	Women < 35 years	Men < 35 years
Anthropometry				
Age	-0.26	0.12	-0.26	-0.09
Height	-0.34	0.03	-0.09	0.01
Weight	0.02	0.31	0.10	0.09
Muscular Strength and Endurance				
Situps	0.15	0.18	0.17	-0.04
Pushups	0.27	-0.07	0.31	-0.16
Combined Max Grip	-0.20	0.13	-0.24	0.05
Endurance Grip	-0.41	-0.08	-0.46	-0.16
Flexed Arm Hang	-0.15	-0.19	-0.07	-0.04
Max ILM to 152 cm	0.12	0.12	0.30	-0.12
Max ILM to 183 cm	0.08	0.14	0.24	-0.17
Aerobic Capacity				
Step Test	0.04	0.33	0.07	0.01
Anaerobic Capacity				
Upper Body (Arm Ergometer)				
Total Work	-0.01	0.20	0.14	0.33
Peak Power	-0.01	0.20	0.14	0.33
Percent Drop Off	-0.02	0.11	-0.16	0.08
Lower Body (Leg Ergometer)				
Total Work	-0.02	0.06	0.06	-0.18
Peak Power	-0.06	0.06	-0.02	-0.12
Percent Drop Off	-0.05	-0.09	-0.21	-0.05

Notes: $r \geq .38$ required for significance at $p < 0.001$.

Table 6.3

Stepwise Regression of Total Number of Sandbags Carried on Fitness by Sex Parameters.

Variables in Equation	B	SE B	Mult *R*	R^2	*F*	*p*
Women < 35 years (n=18)						
Constant	12.79	0.138				
Combined Endurance Grip	0.004	0.002	0.246	0.061	5.621	0.02
Men < 35 years (n=48)						
Constant	14.06	0.786				
Combined Endurance Grip	0.010	0.003	0.505	0.255	13.712	>0.001
Flexed Arm Hang	0.032	0.015	0.576	0.332	9.689	<0.001

task performance, and certainly not the predictors strongly indicated in the previous analyses for the women < 35 years. In fact, only one variable was accepted as significant ($p < 0.001$) in either prediction equation, for men < 35 flexed arm hang, however this fitness item accounted for only 7.7% of the variance. Similarily on the blocked regression analyses, this measure of task performance (i.e., total number of sandbags moved) regressed on the major components of fitness did little to clarify any possible interrelationships (see Table B6.4). All components in the prediction equations were non-significant (at the accepted .001 level of confidence) and most changed $R2_{\text{less}}$ than 10%, the exception being the strength-endurance component for both women and men (i.e., accounting for 11.6% and 22.4% of the variance, respectively).

B6.5 Interpretation

A subset of MPFS requirements was not calculated based upon sandbag carry performance 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 (i.e., under 50 people- 75% of a total of 66 participants). For all other tasks, generally the statistical inferences were much stronger, and results from over 100 participants always determined the 75% who 'passed'.

Table B6.4

Blocked Regression Analysis Regressing Total number of Sandbags Carried on Fitness Components, by Sex.

Block	R^2 Eqn	F Eqn	p	R^2 Change	F Change	p
Women < 35 years (n=18)						
Anthropo metric	0.043	1.26	NS	0.427	1.26	NS
Strength and Endurance	0.158	1.47	NS	0.116	1.53	NS
Aerobic Capacity	0.159	1.33	NS	0.001	0.10	NS
Lower Body Anaerobic	0.204	1.36	NS	0.045	1.39	NS
Upper Body Anaerobic	0.218	1.26	NS	0.143	0.66	NS
Men < 35 years (n=48)						
Anthropo metric	0.008	0.17	NS	0.008	0.17	NS
Strength and Endurance	0.232	1.81	NS	0.224	2.50	<.03
Aerobic Capacity	0.235	1.64	NS	0.003	0.23	NS
Lower Body Anaerobic	0.273	1.50	NS	0.038	0.97	NS
Upper Body Anaerobic	0.306	1.49	NS	0.033	1.29	NS

Therefore, the following conclusions seemed warranted from performance data on the sandbag carry. First, the simplest measures of performance appeared to provide the best evaluative instrument: primarily, the total number of sandbags moved over the 10-min test period, and secondarily, specific lap times throughout the test. This was especially true in the case of the few women tested who were working closer to their maximal strength-endurance capacity. Finally, both the aerobic capacities per se, as well as other measures of fatigue through the task (i.e., drop-off indices), appeared particularly unrelated to performance; this was surprising considering the time (10 minutes) and heavy submaximal nature of this common task.

SECTION B7

PSYCHOLOGICAL PREDICTORS AND OUTCOMES OF PERFORMANCE ON PHYSICALLY DEMANDING TASKS

SECTION B7

PSYCHOLOGICAL PREDICTORS AND OUTCOMES OF PERFORMANCE ON PHYSICALLY DEMANDING TASKS

7.1 Introduction

In an effort to better understand the role and importance of psychological factors in the performance of motor tasks, researchers in the field of sport psychology have examined the issues of whether selected psychological dispositions are related to high level performance in sporting and athletic pursuits and whether specific psychological outcomes accompany superior, average and mediocre performances. Included among the psychological factors shown to predict performance in elite athletes are state and trait indices of self-efficacy. Self-efficacy refers to a form of self-confidence in which one feels capable of performing the behaviour leading to successful completion of the task A "state" measure of self-efficacy refers to the temporary condition of the individual and is situation-specific. By contrast, a "trait" measure of self-efficacy reflects more enduring characteristics of the individual and can be subdivided into perceived physical efficacy and self-confidence. Mood states, affective or emotional states of being, have also been shown to influence performance. The following indices have been identified: i) tension, indicated by heightened muscloskeletal tension; ii) depression, accompanied by feelings of personal inadequacy; iii) anger; iv) vigor-activity, a mood of vigorousness, ebullience and high energy; v) fatigue, a mood of weariness, inertia, low energy level; and vi) confusion or bewilderment. Superior performers tend to display a characteristic profile of scores, across the six mood states. An individual who presents this profile referred to as an "iceberg" profile, is above average on vigor, and normal or slightly below normal on other mood indicators.

One of the most pervasive psychological outcomes of performing a task is attributions; that is, the reason(s) offered to explain the outcome of an achievement attempt. Attributions can be classified in terms of stability, and locus of control. Many studies have demonstrated an egocentric bias, wherein success is attributed to such stable, internal factors as ability and effort, but where failure is attributed to external, unstable factors such as task difficulty and luck. Gender differences have also been noted in attribution studies. Women are less likely than men to employ ability attributions to account for success, and/or lack of effort to account for failure.

Internal psychological dispositions, both state and trait (eg., personality), have been found to account for a limited percentage of variance in behaviour and performance. In this section, situation and personality by situation interactions are examined.

B7.2 Task Rationale

Although much of the research has been conducted on elite athletes in sporting activities, it is conceivable that similar factors contribute to performance in work-related athletic activities. Therefore, in the present study the influence of psychological factors on task performance was assessed relative to the stretcher carry and the low high crawl. These two tasks were chosen specifically because of their demonstrated difficulty (i.e., according to MPFSI results). Four hypotheses were examined, specifically: i) that self efficacy (both state and trait measures) would be a significant predictor of actual performance; ii) that better performers would display an 'iceberg profile' prior to task performance; iii) that superior male performers would demonstrate a self-serving attributional bias and thus, relative to their mediocre-performing male counterparts, would be more likely to attribute success to ability and effort; conversely, that superior female performers would not demonstrate a self-serving bias but would show an attribution pattern similar to that of their mediocre-performing counterparts; iv) that psychological factors would account for only a limited percentage (at best 20 %) of the variance in performance.

It was felt that investigation of psychological factors in addition to the fitness variables studied would assist in the explanation of task performance. Ultimately, it was hoped that a better understanding of the importance of psychological factors in performing motor skills would be obtained, there by providing additional insight to be used for the improvement of assessment and practice/training procedures.

B7.3 Protocol

This facet of testing was conducted at CFB Ottawa only. A total of 62 men and 72 women participated.

All variables were assessed using questionnaires available in both French and English versions which were administered at three designated times. At the general meeting, following initial briefing of subjects, participants were asked to complete a questionnaire which assessed trait self-efficacy, beliefs and expectancies. Then immediately prior to and following performance of each of the stretcher evacution and low high crawl tasks, pre- and post-task questionnaires were administered; these latter were designed to assess psychological states relative to each specific task. The pre-task questionnaire included items assessing state self-efficacy, expectancy, mood state (Profile of Mood State (POMS); McNair et al., 1971) and state anxiety. Included in the post-task questionnaire were the POMS, and ratings of perceive performance and rate of perceived exertion (RPE; Borg, 1970).

Questionnaire data were analyzed mainly through descriptive statistics such as means, standard deviations and regression analyses. Then, the basis of their actual performance scores, subjects were divided into three groups of equal size, reflecting superior, average and mediocre performances. Conducted separately for both the low high crawl and land evacuation tasks, this experimental protocol allowed us to test some of the hypotheses previously outlined.

B7.4 Results

Self Efficacy

Perception of physical self-efficacy (trait) accounted for 12 percent of the variance in the low high crawl (after removing effects of sex and age). The state measure of self-efficacy accounted for 4 percent of the variance in the land evacuation task (after removing effects of sex and age).

Mood State

Male superior performers on both tests displayed an iceberg profile prior to performance. Mediocre male land evacuation task performers demonstrated an iceberg profile prior to performance; mediocre performers on the low high crawl task demonstrated well above average levels in all mood state indices.

Female superior performers displayed an iceberg profile prior to low high crawl performance but showed above-average levels of tension, depression, anger, vigor, fatigue and confusion prior to performance in the land evacuation task. Female mediocre performers demonstrated above average levels of mood state prior to performance on the low high crawl whereas mediocre evacuation task performers demonstrated unusually high levels on all mood state indicators.

Following performance in the low high crawl, superior and mediocre performance males demonstrated a large decrease, relative to their pre-task profile, in all mood indicators; this drop was, however, more pronounced for mediocre performers. Female mediocre performers showed a marked decrease in mood state indicators whereas the profile of their superior-performance counterparts remained about the same.

Following performance on the land evacuation task, the mood state profile of male and female superior and mediocre performers remained consistent with that observed prior to task performance.

Attributions

Consistent with the hypotheses, male performers demonstrated a self-serving bias in attributions. Superior performers attributed success mainly to talent and effort (internal); mediocre performers attributed performance to task difficulty and, to a lesser extent, lack of effort (external). This pattern was observed for both tasks.

By contrast, women did not exhibit a self-serving bias. Superior and mediocre performers on the low-high crawl evidenced similar attribution patterns. However, for the land evacuation task, superior performers attributed performance to effort, whereas mediocre performers attributed performance to task difficulty.

Personality

Psychological factors account for approximately 20% and 23% respectively, of the variance in performance on the low high crawl and land evacuation tasks. However only trait and state indicators of self-efficacy, respectively, proved to be significant performance predictors on these tasks (i.e., low high crawl, and land evacuation).

B7.5 Conclusion

In light of the previous results and discussion, the following conclusions seem warranted:

1. Psychological factors play an important yet limited role in predicting performance on motor tasks in normal adults.
2. Self-efficacy, or a person's beliefs in his/her performance capabilities, seems paramount in predicting superior performance.
3. Performers' mood states interact with situational

requirements and task demands resulting in inconsistent patterns prior to and following performance.

SECTION B8

LIST OF REFERENCES

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APPENDIX A

M.P.F.S. II CONTRACT PROPOSAL

D R A F T

A2

PROPOSAL

DEVELOPMENT OF MINIMUM PHYSICAL FITNESS STANDARDS FOR THE CANADIAN ARMED FORCES (PHASE II)

submitted by

ERGONOMICS RESEARCH LABORATORY
QUEEN'S UNIVERSITY AT KINGSTON

Principal Investigator

Joan M. Stevenson, Ph.D.
School of Physical and Health Education

Collaborative Investigators

George M. Andrew, Ph.D.
School of Physical and Health Education

J. Timothy Bryant, Ph.D, P.Eng.
Department of Mechanical Engineering

John M. Thomson, Ph.D.
School of Physical and Health Education

to

DEFENCE AND CIVIL INSTITUTE
OF ENVIRONMENTAL MEDICINE

SUBMISSION DATE: January 31, 1986

BACKGROUND

One year ago the Applied Physiology Section at DCIEM was tasked by the Director of Physical Education and Recreation Amenities (DPERA) to develop Minimum Physical Fitness Standards (MPFS) for the Canadian Forces (CF). These standards will be based upon seven common military tasks and will apply to all CF Personnel regardless of trade, classification, age, or sex. The ground work for the present proposal was prepared, initially, by our earlier contract (DSS #8SE85-00017), and in our final Report to DCIEM submitted this past fall. In essence, Phase I revealed that EXPRES was a reasonable measure of general physical fitness and that the tasks evaluated have at least 20% of the final score attributable to fitness levels. However it was not possible to predict performance in these tasks from fitness measurements alone. At this time we propose that Phase II of the research should continue according to the schedule recommended in the original with specific modifications in the Workplan based upon our Pnase I experience.

In order to assist with the development of minimum physical fitness standards, an empirical model was developed based on minimum scores of the passing male population only. Because the of empirical nature of the model, the type of sample distribution and the problems contained in task definition, a validation study is necessary for the male population. In addition, the standards in the Phase I report cannot be extrapolated to females. Hence a large scale study of female personnel must also be conducted. As a result of the need to verify standards, this aspect has been selected as a **Primary** Objective for Phase II of the contract.

An additional concern indicated in the Phase I report was the arbitrary nature of task definition. The fitness component was also extremely difficult to isolate from other confounding variables such as experience or problem solving. As a result of these concerns, a set of **Secondary** Objectives have been established to alter and improve task performance assessment.

Primary Objectives of MPFS II

As a continuation of Phase I, the applicants feel that additional research is both warranted and urgently needed in two areas:

OBJECTIVE #1.

To continue to upgrade the Minimum Fitness Standards recommended for males in the Canadian Armed Forces.

Rationale. The standards established in Phase I then subsequently recommended by DPERA for implementation into the Canadian Forces were established according to an empirical statistical model and therefore have serious shortcomings as emphasized in the final report. While these standards provided an initial step towards MPFS, they must be upgraded. To this end, the present proposal defines specific populations, directions, and procedures, including test additions (as well as deletions) and the refinement of specific protocols.

OBJECTIVE #2.

To establish Minimum Fitness Standards for females in the Canadian Armed Forces.

Rationale. In the first Phase, a sample size of 18 female subjects was the largest sample on any single test item. In addition, the majority of women possessed superior fitness levels, particularly the 13 females studied in Halifax. These two shortcomings placed serious limitations on any statistical analyses towards development of MPFS. Therefore, it is proposed that 100 female subjects be studied, ranging in age from 20 to 29 years and possessing fitness levels which span a wider spectrum, as determined by their EXPRES score values.

Secondary Objectives of MPFS II

The Task performance assessments used in Phase I were discrete universal criteria such as carrying the land stretcher in a time of twenty minutes. Through statistical correlations, results revealed that at least 20% of the subjects' scores were related to fitness (as defined by EXPRES or additional laboratory tests). The difficulty of the tasks warrants a belief that task criteria are not adequate to filter out the fitness component without interaction from other variables such as motivation, skill, or ingenuity. These interactions are summarized in the conceptual diagram illustrated in figure 1. Each rectangle represents a process model by which several input variables are combined to produce a single output variable, the task performance score. The nature of these variables are not defined specifically in all cases, but serve to illustrate the interaction between several processes.

Human activity is viewed as a process of energy conversion by which fuel is burned to eventually achieve performance in a

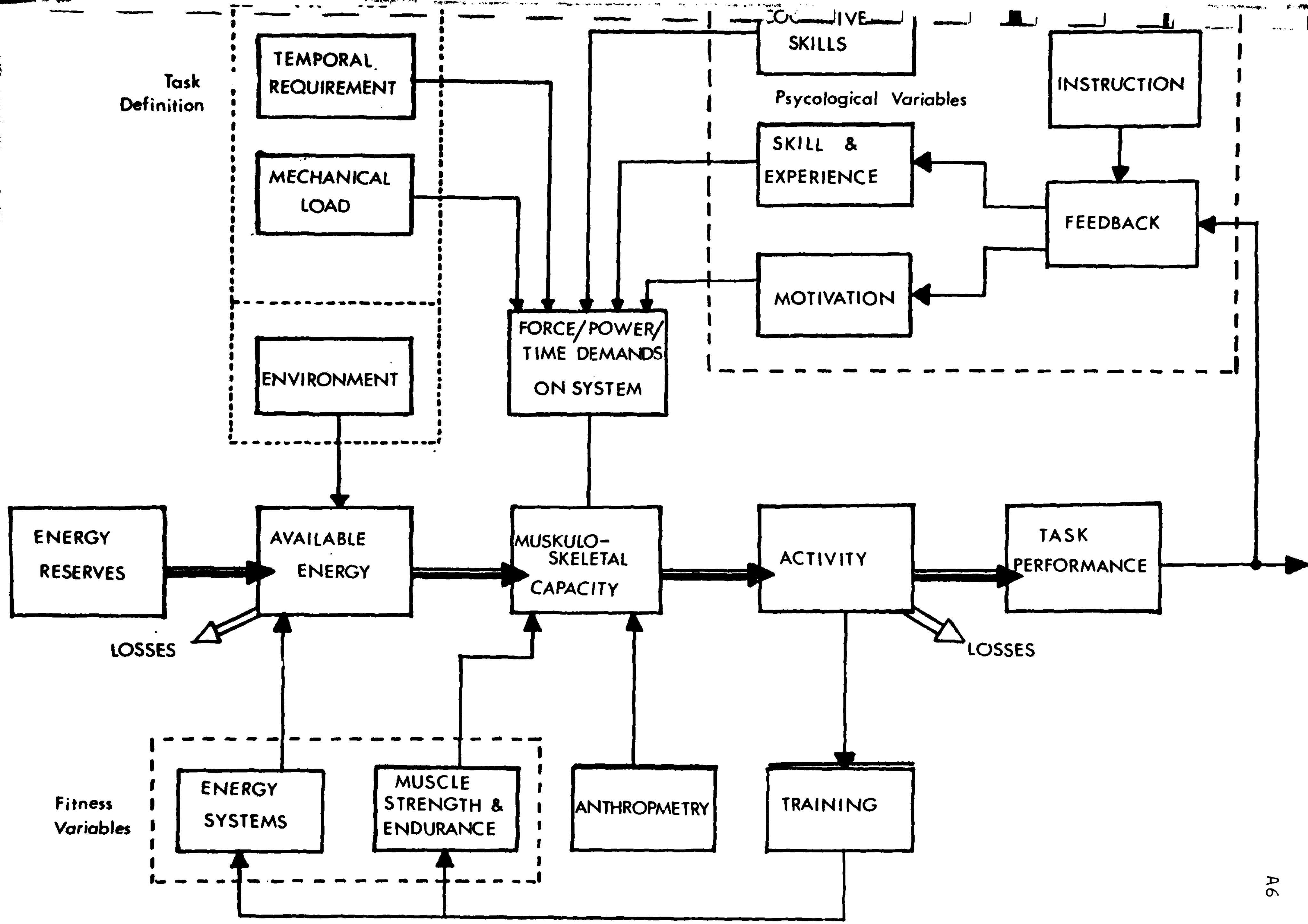

Figure 1. Conceptual Model of Factors affecting Task Performance.

particular task. The main energy pathway is shown as a series of bold lines passing through a set of discrete processes. Starting at the rectangle labeled Energy Processes, energy is made available for work through the influence of the environment and various energy mechanisms. Losses are incurred in this process so that not all fuel sources become available for mechanical work. The capacity process is a complex biomechanical system by which energy is converted to force in the muscles, and the action of focus within the musculoskeletal system executes a pattern of activity as determined by the central nervous system. The activity itself has losses which relate to motions not directly associated with task performance. Nevertheless, the task itself is performed and is assumed to be gradeable in some way.

The illustration of Figure 1 indicates many of the variables which influence this pathway. Two key loops are noted in the psychological feedback loop and the training feedback loop. In the former, feedback is obtained through instruction to alter the skill and experience or the motivation of the subject. These factors, combined with cognitive skills are thought to influence system demands identified by the "Force/Power/Time demands on system" module. This process represents the mental formulation of the task in terms of central nervous system signals to be sent to the musculoskeletal system. Implicit is the input from the temporal and mechanical requirements of the task itself.

The training feedback loop influences two big variables, namely energy systems and muscle strength and endurance. Energy systems are though to encompass anaerobic and aerobic mechanisms required to convert food to energy sources to be used by the muscles. Muscle strength and endurance influence the ability to convert this energy to forces of specific magnitude and duration.

These interactions illustrate the problem of naming a few variables in an attempt to measure the whole system. In order to determine what portion of task performance is related to fitness, various alternate assessment techniques will be studied.

Figure 2 represents the relationship between a theoretical performance level and actual performance level. This relationship between projected work rate and actual work rate, called the drop-off index, is due to the demands of the task. It may be possible not only to investigate an individual's capacity for work but also to know the drop-off in work rate due to muscular fatigue. This technique of analysis can provide further insight into the demands of the task as well as the individual's capability to perform the task.

Figure 3 represents another concept of work rate evaluation. In this example, the demands of the task are varied and the ensuing change in the individual's response to the load is measured. The subjects' response can be mathematically modeled as an exponential curve. The hypothesis in this case is that the load curve will provide insight in to the fitness/fatigue level of the individual. Only two tasks, the land stretcher carry and sand bag loading, will be studied under these alternate models of assessment. If these procedures prove both statistically and

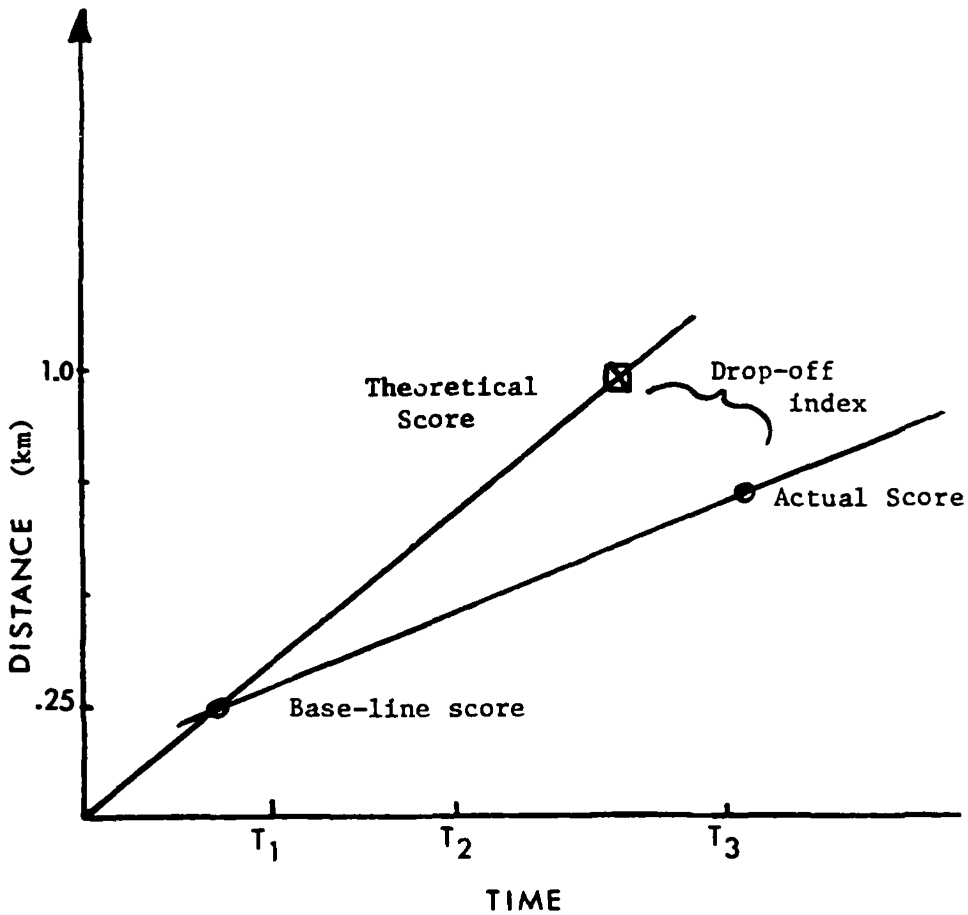

Figure 2. The drop-off index is the difference between the theoretical performance extrapolated from a baseline measure and actual performance on a task of a given demand.

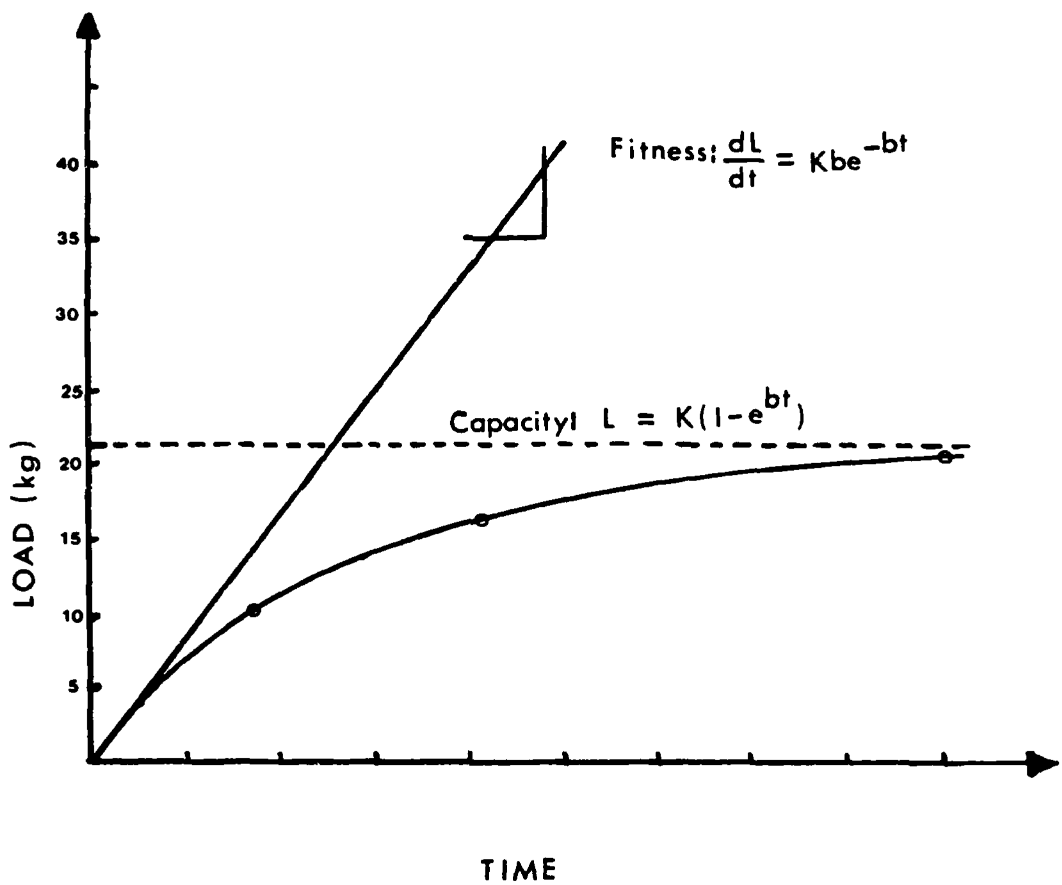

Figure 3. This profile represents one individual's work rate response to increasing load increments where L_1 is the maximum load an individual can lift (i.e., his/her maximum capacity). The Fitness component is derived by looking at the rate of drop-off between loads.

methodologically viable in preliminary studies, then the proposed field study, will also serve as important objectives of this research.

OBJECTIVE #3.

To examine the repeatability of a number of tasks.

Rationale. If the task criteria is subject to a great deal of day-by-day variability, then the measure is not sufficiently reliable to measure performance. Over consecutive days (i.e., 5-10 days) repeated trials will be performed to study inherent (daily) variability of the established protocols (according to MPFS).

OBJECTIVE #4.

To conduct a biomechanical assessment of tasks in regard to CF Personnel safety.

Rationale. Each task places CF Personnel in a potentially awkward posture which could be considered unsafe in terms of the torque applied to the lower back. Using prepackaged software routines, a static analysis of various subjects in various postures during tasks will be assessed based on the NIOSH standards. This research may assist the military in screening out tasks that may employ unsafe task criteria.

OBJECTIVE #5.

To study the effect of the Drop-Off Index of performance as it relates to fitness.

Rationale. Another approach that appears promising is to determine drop-off indices for various tasks and relate these to subject fitness. For example, the land stretcher will be carried for 1 km by the subject but without any weight; this would represent his/her best performance for completion of the task within the restrictions of the task protocol (i.e., without running or jostling the imaginary wounded evacuee). Then, with the stretcher 'loaded' according to task protocol (i.e., with 80 kg), the task would be repeated and the subject's performance decrement - actual test results (time, physiological responses, etc.) compared to the theoretically best score for that subject - then related to fitness levels (see Figure 2).

OBJECTIVE #6.

To examine the concept of a Progressive Incremental Approach to evaluate fitness.

Rationale. One of the new concepts felt worthy of study is to carry out another approach of task definition which involves studying the subjects under variable loading conditions. For example, the weight of the sand bags being carried begins at a reduced load and is increased incrementally to the weight specified by the task description. Decrement in performance times, and the biomechanical and physiological responses of subjects would then be related, statistically, to subjects' physical fitness (see Figure 3).

Work Plan: Phase II

Following, a summary of the proposed work plan is outlined. Basically, it incorporates the same scheduling followed in Phase I with minor alterations. This schedule met both the time constraint required by DPERA while enabling the applicants to fulfill contractual obligations; again, a September briefing is proposed (as required by DPERA) with a November 30th deadline for submission of final Report.

Details of Work PLan

1.1 Preliminary Studies. Including literature review and update, preliminary work will be conducted to further refine and/or modify various testing procedures, and to revise biomechanical and physiological evaluations associated with the conduct and scoring of several tasks. From Phase I there are several new ideas and concepts for solving various problems encountered:

i) A series of Repeatability Studies on the established task protocols, to determine the day-to-day variability inherent in these protocols.

ii) On two specific tests, Land Stretcher Carry and Sand Bag Carry, alternate methods of assessment will be studied, specifically: incremental loading protocols will be developed for each task as well as performance drop-off indices established, with these results being related (statistically) to subjects' levels of fitness.

It is felt that these preliminary studies are necessary, first, to validate what portion of task performance is related to fitness (i.e., in Phase I, 20% was determined to be a minimum value in this regard) and second, to determine what fitness measures serve best to predict task performance. In the first instance therefore, based upon our Phase I findings, a model for

WORKPLAN SUMMARY FOR PHASE II

TITLE	OBJECTIVES	SITE	STARTING DATE	COMPLETION DATE
1.2 Preliminary Studies	1. Update of Literature Review 2. Modification of Methodologies 3. Establishment of New Test Protocols	Q.	21 Apr 86	5 Jun 86
1.2 Field Study	Performance Rating for Tasks #3, #4 & #6* Week 1: 100 Male CF personnel Week 2: 100 Female CF personnel	CF	9 Jun 86	24 Jun 86
1.3 Data Analysis	Correlation of Performance Ratings on Task and EXPRES** Evaluation	Q.	1 Jul 86	15 Sep 86
1.4 Documentation	1. Preparation of Report 2. Summary of Report: Briefing	Q.	15 Sep 86 30 Sep 86	30 Oct 86 -

* See Table 1 for particulars.

** It is requested, again for Phase II, the DPERA provide recent EXPRES data on each subject; this proved a major assistance in Phase I.

Q.: Queen's University, at Kingston.

CF: A Canadian Forces Base (exact site undertermined at date of proposal submission) accurately assessing performance on various tasks to which particular fitness parameters can be related and compared must be developed. Finally, it is proposed that several new tasks be included in addition to the tasks studied in Phase I (see 1.2 below) and these also will require preliminary work to finalize the protocols. Similarly, a number of additional laboratory tests will be examined for possible inclusion in the Queen's station.

<u>1.2</u> <u>Field Study</u>. In Table I below, a schedule for one week is outlined. Over the week, it is proposed that 100 subjects be tested; thus at the 9 Test Stations, the subjects (all of the same sex preferably) will be divided into 9 groups of 11 subjects each (with the last group having 12 subjects). Each group will rotate, according to numerical order, each half day to the next station. It should be noted that in addition to modified testing protocols, two additional tasks are proposed:

a) Sand Bag Carry

b) Queen's Task - This task will involve repetitive lifting, to load one ton of 30-50 lb. sand bags onto a military truck bed, 1.35m in height.

<u>1.2.1</u> <u>Subject Selection</u>

In Phase I, statistical dispersion of the task results were estaolished for the male subjects, and on the limited number of female subjects. Based upon this data spread, therefore, for statistical significance in Phase II it is calculated that 100 males and 100 females should be studied. Further, based upon their mean EXPRES scores (see footnote of Work plan summary) these subjects should be drawn from a much broader fitness

TABLE 1: FIELD STUDY SCHEDULE FOR ONE WEEK: EACH GROUP OF SUBJECTS IN NUMERICAL ORDER WILL MOVE TO THE NEXT STATION EACH HALF DAY

	ONE DAY	ONE DAY	ONE DAY	ONE DAY	ONE DAY
	STATION 1	STATION 3	STATION 5	STATION 7	STATION 9
3 Hour Time Block	1LM* (2 Testers) EQUIPMENT: Tent, Tables Computers, etc.	Entrenchment Dig (2 Testers) AREA & EQUIP: Digging Area/ with consistent soil conditions, Entrenchment Tools	Land Stretcher Carry (2 Testers) AREA & EQUIP: 400 metre Track Land Stretchers weighted to 80 kg	Incremental Land Stretcher Carry * (2 Testers) AREA & EQUIP: 400 metre Track Land Stretchers and weights	Queen's Task * (Truck Load (2 Testers) AREA & EQUIP: - Truck Bed (1.35 m HT.) - Sand Bags (50 lbs)
One Hour Time Block	L U N C H	B R E A K	E A C H	D A Y A T	N O O N
	STATION 2	STATION 4	STATION 6	STATION 8	MAKE UP TESTING AND ANY RE-TESTING - Subjects will proceed to Test Stations accordingly
3 Hour Time Block	Lo-Hi Crawl* (1 Tester) AREA & EQUIP: Field Chutes	Sea Stretcher Carry (2 Testers) AREA & EQUIP: Gang-Way Stairs (2-story structure) 1 Shipboard Stretcher	Sand Bag Carry* (2 Testers) AREA & EQUIP: Field Sandbags (50 lbs)	Incremental Sand Bag Load* (2 Testers) AREA & EQUIP: Field, Various weighted sandbags (10-50 lbs)	

*Indicates modified Task Protocol/or New Tests Proposed spectrum; specifically, less fit persons in both populations must be studied. Thus there should be 25 subjects under the 25th percentile, 25 subjects from 25th to 50th percentile, 25 subjects from the 50th to 75th percentile and 25 subjects above the 75th percentile. Finally, to maximize statistical power, both groups should include only subjects 29 years of age and younger (and this aged population includes the majority of CF Personnel, in any case). Based on the number of EXPRES scores taken thus far by DPERA and based on the fact that individuals do not change their social habits very quickly, it is surmised that finding appropriate Forces Personnel in each fitness category will be possible.

1.2.2 Summary of Tasks: Station 1

Station 1 will consist of the Incremental Lifting Machine (ILM), with displacement/velocity transducer and microcomputer data processing unit. From Phase I some of the ergometry, endurance and blood analyses carried out at the 'Queen's Station' will be replaced by additional strength measures using the Marci bench press, military press, submaximal lifting tests, as well as the established ILM test protocol.

Station 2. Lo/Hi Crawl. Because of the differences in crawl techniques noted in Phase I yet the importance of the agility/speed component of this common task, in Phase II a wire chute of appropriate height (40 cm (18 in.) in height for the Low Crawl portion, 66cm (30 in.) for High) will provide an enclosure over the course; if the Helmet, back or any part of the soldier's equipment touches the top portion of the chute, time will be deducted from the subject's score. This addition to the test methodology and the inclusion of a no-load practice trial, will assist with the standardization process.

Station 3. Entrenchment Dig. The major requirement for this task (repeated from Phase I) will be soil conditions as specified in DPERA guidelines[1]; otherwise, this task and protocol will be repeated according to the methodology established in Phase I.

Station 4. Sea Stretcher Carry. Essentially, the protocol will remain unchanged from Phase I, however some changes are suggested:

i) As the fire-fight station will not be attempted in Phase II (all subjects easily completed this task in Phase I), the facilities of CFB Halifax Fire-Fighting Training School will not be required; therefore, there may be modifications in the actual physical set-up for the stairs and top-deck at this station at the testing locale chosen.

ii) The criteria for matching subjects in this 2-person task will be revised; this is another, minor, independent study slated during preliminary work at Queen's.

Stations 5 and 7. Land Stretcher Carries. These tests will be attempted on alternate days and at the same time of the day. While the task is essentially unchanged from Phase I (i.e., evacuation simulation of a wounded, 80 kg person over 1 km), the incremental testing station (no.7) will involve completing the task carrying different loadings, up to a maximum of 80 kg.

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[1] however these are NOT found in the Kingston area in June-August.

Station 6. It is planned that the sand bag carry, which was eliminated in pilot studies of Phase I will be returned to the task battery with the requirement being, how many 22.7 bags (50 lb.) can be moved to a distance of 50 m in 10 minutes. Although no fixed criteria score has been established for this protocol, it is felt that this approach will not only allow us to examine the original task standard (8 sand bags in 10 minutes) but also to examine drop-off in carry rates due to fatigue.

Station 8 and 9. A new task will be added which most closely replicated the most common type of military lifting tasks. It is speculated that this task will be to load 27.7 kg. (50 lb.) sand bags onto a military truck bed of 1.35m in height. The time taken to load one ton will be evaluated and the subjects' physiological responses measured. In Station 9 the load increments will be varied to examine the relationship between load size and fatigue.

1.2.3 Assessment Measures.

Subjects' fitness will be assessed according to several methodologies, however not all of the parameters measured in Phase I will be repeated. Each parameter will be re-assessed based on Phase I data and re-evaluated during pilot studies. Principally, physical fitness will be determined by individual EXPRES scores, each subject's mean EXPRES score and ILM strength and kinetic variables. On the other hand, performance assessment on each task will involve a number of varied measurements, principally, time to completion of each task and the physiological stress of the various protocols. These latter data will be determined directly by Heart Rate Telemetry (on as many subjects as possible) and using the Vol-Ox System (mask, accessory apparatus, etc.). As well, during the completion of particularly strenuous tasks, considering the low fitness level of ome of the subject population and from the standpoint of safety, heart rate telemetry is deemed both essential and critical.

1.3 DATA ANALYSIS

Using methods previously established for MPFS-I, correlation of fitness scores and performance rating will be undertaken. Again, techniques of simple correlation, multivariate correlation, and the method of principle components analysis will be used; statistical results will attempt to identify those fitness factors most indicative of task performance. As well, the empirical model developed in Phase I will be applied to these similar test data to compare Phase II results with those obtained in the first phase.

Budget Proposal for MPFS II

- Detailed Budget
- Budget Justification
- Equipment Quotes

Table 1. Detailed Budget

A. Labour:

1. Principal Investigator	$150.00	28 days	$4,200.00
2. Administrative Assistant	$1,400.00	6 mos.	$8,400.00
3. Task Co-ordinator	$1,200.00	6 mos.	$7,200.00
4. Research Assistants	$1,000.00	3 @ 3 mos.	$9,000.00
5. Clerical Assistants	$250.00	2 wks.	$500.00
6. Student Assistants	$225.00	11 @ 3 wks.	$7,425.00
7. Subjects ($5/hr.)	$187.50	10 @ 3 wks.	$5,625.00
8. Fringe Benefits	10% of Labour costs		$4,235.00
	TOTAL ESTIMATED LABOUR		$46,585.00

B. Consumable Materials and Supplies:

1. Printer and Switches	$700.00
2. Computer disks, ribbons, paper, pens	$1,000.00
3. Safety equipment and supplies for testing	$500.00
4. Phone calls	$500.00
5. Computer phone line rentals (2 for 6 mos. @ $30/mo.)	$360.00
6. Photocopying and duplicating (ie. related literature)	$600.00
7. Final Report (i.e., type set; reproducing)	$1,000.00
8. Physiological Supplies (eg., electrodes; re-agents)	$500.00
9. Biomechanical Supplies (eg., film; WATBAK analysis)	$800.00
10. Software (Basic Compiler & LABPAC)	$800.00
11. Modem and line installation to mainframe	$700.00
12. Computer table and chair	$500.00
TOTAL ESTIMATED CONSUMABLES	$7,960.00

C. Travel and Living:

1. Kingston Travel (CFB Kingston)	$1,000.00
2. Conference Travel	$1,000.00
TOTAL ESTIMATED TRAVEL	$2,000.00

D. Direct Charges:

1. 4 Wheel Systems for stretchers	$2,000.00
2. Return system for sandbags	$600.00
3. Low-High Crawl	$1,000.00
4. Entrenchment Dig (build boxes)	$500.00
5. Build Sea Stretcher Platform	$3,000.00
6. Convert Marci for military & bench press	$1,500.00
7. STATLAB	$500.00
TOTAL ESTIMATED DIRECT CHARGES	$9,100.00

E. Computer Costs:

1. Final Statistical Analyses and Report on University Mainframe Computer	$1,000.00
TOTAL ESTIMATED COMPUTER COSTS	$1,000.00

F. Equipment:

1. Self-contained Metabolic Measurement System (VOL-OX)	$2,503.60
2. 4 PE-3000 Pulse Rate Monitors ($425.00 each)	$1,700.00
3. 4 Telemetry Units ($12,000 U.S. + 50%)	$18,000.00
TOTAL ESTIMATED EQUIPMENT	$22,203.60

G. Rental:

1. Queen's Fitness Centre Research Equipment, Testing and Services	$1,000.00
TOTAL ESTIMATED RENTAL	$1,000.00

H. Overhead and Administration:

1. 65% of Items A and B	$35,454.25
2. 2% of Item C	$40.00
TOTAL ESTIMATED OVERHEAD	$35,494.25

TOTAL ESTIMATED BUDGET	$125,342.85

Budget

The Budget of $125,342.85 is proposed to cover the cost of the required scientific testing for this project. The assumption is made that all testing would be conducted at Kingston, and that the military would assume responsibility for transporting personnel acting as subjects to that site. Should it be required to test at a different location, the budget would be revised.

Justification of Budget

A. Labour

Seven main items are considered in the personnel budget as detailed below.

Administrative Assistant: Based on our experiences in the last MPFS contract which, like the present contract, involved employment of a large number of people and data collection on many subjects within a relatively short period of time, it is essential to have an 'administrative' person for the on going management of the contract; specifically, this position will comprise co-ordination and scheduling of personnel and subjects during data acquisition, daily budget management and equipment acquisition. In addition, the administrative assistant will be responsible for statistical design and analyses for the project. Fortunately, this person[1] is already available to undertake this

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1 It is anticipated that this person will be available to provide statistical assistance to the OPSS contract held concurrently. Likewise, technical expertise will be obtained from the OPSS contract research assistant.

project and will provide a sense of continuity from MPFS I.

Task Co-ordinator: A task co-ordinator is required for analysis and development of task protocols, according to the contract, review of literature and application of tasks. This person will be responsible for training research assistants in the technique of data acquisition and analyses, especially for the period(s) of mass testing.

Research Assistants: Three research assistants are required for managing specific subprojects. The students selected generally will have a background in physiology and/or biomechanics (as required) and will be employed in the laboratory for three months only, from May until July. They will be responsible for pilot data collection on specific tasks, task refinement, and on-sight data collection. In addition, it would prove especially fruitful to maintain the services of these individuals for data entry in that they would be immediately aware of any irregularities or peculiarities evidenced in the raw data. As well, such assistance in the data entry stage would markedly reduce the time lag between the data collection and analyses stages[2].

Clerical Assistance: is required for the preparation of reports. The majority of this activity will be conducted outside the time constraints of the main staffing and thus will warrant an additional two weeks of clerical support.

Student Assistants: Eleven student assistants are required

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[2] It is anticipated that these individuals could act as research assistants for specific phases of OPSS which will have a component of data acquisition and analysis in August.

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Task Co-ordinator: A task co-ordinator is required for analysis and development of task protocols, according to the contract, review of literature and application of tasks. This person will be responsible for training research assistants in the technique of data acquisition and analyses, especially for the period(s) of mass testing.

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for the two weeks of data collection involving military personnel. These people will also be required to undergo training in the data collection techniques required. This will constitute an additional one week of employment for each of these assistants.

Student Subjects: The equivalent of 10 full time employee subjects will be required in the pilot phase of the project to improve task protocols, check task reliability and develop new protocols.

B. Consumables

General laboratory equipment and supplies total $7060.00. These include special supplies required for photocopying and document preparation, as well as safety equipment required for the pilot testing phase. Whether planned expenses or unexpected repairs, the consumables budget is always critical to the smooth running of the project.

C. Travel and Living

Based on our past experience in testing recruits on a CF Base, substantial funds are required despite the short travel distances. The equipment used is bulky and requires rental of trucks and movers. An additional item is requested for travel to conferences on the part of researchers.

D. Interdepartmental Costs

The usual way of handling specific areas of research at Queen's is to consult one of the many areas of specialization. In this contract, we have included resources from two general areas of expertise. Modifications in the protocols of task performance are required to increase the objectivity of the obtained measurements. In all cases, this will require, to a greater or lesser extent, (re) design of the testing equipment employed. The main expenses will be construction of devises to standardize task protocols. For example, a wheel system must be created to allow the stretcher carry to be a single subject task. Other items are required to standardize tasks requirements (i.e., a screen to keep personnel low on the crawl, a uniform dig situation and uniform sand bag placement). The sea stretcher platform is required to create the same vertical elevation and thus, physiological demand as the shipboard situation. Both the ILM and Marci will be activated to create simple but effective test items within the Queen's Station. The anticipated costs for these items are listed in the preceding table. In addition, a group of professional statisticians in STATLAB will provide expertise in experimental design and analysis. This consultation will be necessary because of the addition of drop-off indices and incremental loading test designs.

E. Computer Costs

Final statistical analyses and report preparation will require use of the Queen's mainframe computer. This quote is based on the standard price breakdown incorporating connect and C.P.U. time used for contract research.

F. Equipment

The equipment items required for the contract are primarily to ensure the safety of the participants during performance of these very stressful tasks; however, each item has a discrete function. The self-contained metabolic measurement system is required for continuous measurement of respiratory volumes and oxygen uptake. This is especially important for monitoring the physiological stress levels of specific tasks before expecting the older age groups to attempt the task. Identification of stress points with the younger age groups will also allow necessary changes to be made to the protocols to ensure the safety of the older age groups. Four EKG telemetry units (allowing simultaneous physiological measurement of four individuals) are required for those tasks in which several subjects are performing at once. The proposed units will be used with an existing recording system. Pulse rate monitor units will provide sufficient information for monitoring of the less demanding tasks. Since the emphasis of this contract is on women and it is known that these tasks are extremely strenuous for this group, it is felt that we must be especially conscientious in monitoring the physiological demands of the tasks and in ensuring the safety of our participants.

G. Rental

Rental of the Queen's Fitness Centre will be required as a 'testing ground' for pilot studies which will involve standard anthropometric scaling, somatotype and selected physiological and strength measurements.

H. Overhead and Administration

The usual overhead of 65% on salaries and consumables and 2%

on Travel has been charged.

RANSKINETICS

TRANSKINETIC SYSTEMS, INC.
110 Shawmut Road
Canton, Mass. 02021
617-828-3000 (MA)
800-441-6018 (outside MA)

QUOTATION

NO. 86-159

DATE: 1/16/86

TO:
JACK DUBEAU DPT. PHYSICAL HEALTH EDUCATION
QUEENS UNIVERISTY
KINGSOTON, ONTARIO K7L-3N6

SALESMAN —

MS	DELIVERY	
NET 30	45 - 60 DAYS	F.O.B. CANTON, MASS.

ITEM	QUANTITY	PROD. CODE	DESCRIPTION	UNIT PRICE	AMOUNT
1	4	20	TXM-205 TRANSMITTERS*		
2	4	25	TXR-206 RECEIVER MODULES		
3	1	35	TXE-206 RECEIVER ENCLOSURE		
4	2	50	AN-16 DIPOLE ANTENNAS IWTH 25 ' CABLE		
5	1	60	MC-500 CALIBRATOR		
ACCESSORIES					
1	1	80	6 PKG TMBS -015 BATTERIES		
2	2	80	ROLL TMCZ-110 F CHART PAPER		
3	2	80	TMTT-001 TUNING TOOLS		
4	8	80	TMEL-020 20 CM. LENGTH ELECTRODE LEADS		
					$12,000.00

This quotation is in effect for 60 days from date shown. The company reserves the right to accept or reject all orders at time of placement. Shipping point is factory shipping dock at Canton, MA. Prices quoted do not include any applicable taxes, unless shown on quotation.

WARRANTY - ONE YEAR PARTS AND LABOR

* SUBJECT TO 5 YEAR LIMITED WARRANTY

BY: [signature]

CUSTOMER

Ancansco

85 Nugget Avenue
Agincourt, Ontario M1S 3B1
Phone: (416) 291-3336
Cable: ANCANSCO Toronto
Telex 065-25315

January 25, 1986

Queens University
Dept. of Physical Education
Kingston, Ontario
K7L 5N6

Attention: Dr. J. Stephenson

Subject: Our Quotation No. 0-4169-0186

Dear Sirs:

Further to your recent telephone conversation we are pleased to quote you as follows.

(1) - 810-00112-7 FC112 Respiratory and tidal volume coupler.........$ 673.00
(1) - 810-54041-7 RT1 12 flow transducer.............................$1,278.00
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(1) - 810-54044-0 Coupling mask (for use with RT112 & OX140
transducers..$ 157.00

F.O.B. AGINCOURT - NET 15 DAYS - TAXES AND DUTY EXTRA IF APPLICABLE
Prices subject to confirmation at time of ordering

We trust that the above will prove of interest to you and if you should have any further questions please do not hesitate to contact us.

Yours very truly,

ANGLO CANADIAN SCIENTIFIC CO. LTD.

Robert C. Williams

RCW:lm

APPENDIX B

ETHICS REVIEWS: DOCUMENTATION AND CORRESPONDENCE

School of Physical and Health Education

Queen's University

Minimum Physical Fitness Standards Study: Phase II

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards (MPFS) for all military personnel. The underlying principle is that there are certain duties which all personnel must be able to perform if called upon in an emergency. Several common tasks have been identified by the CF as being critical.

In April, 1985, Queen's University was contracted by the CF to investigate the specific fitness requirements of these tasks. The ensuing testing 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. Queen's has once again been contracted by the military to continue the investigation of the fitness requirements of the stated military tasks, and to verify and/or modify the standards initially proposed. The purpose of the present study is to assess (and improve where necessary) the psychometric properties of the military tasks as initially performed. This will include investigation of the effects of practice, and the reliability and validity of the tasks.

Testing Procedures

Subjects will be approximately 100 females and 100 males aged 20 to 40 years who are in good health. The experimental protocol will involve a preliminary session in which subjects will be briefed about the purpose and nature of the study, and will complete a questionnaire which will provide a personal history of general activity, identify and describe any physical problems that may hinder performance. Subjects will also be measured for height, weight, girths and limb-lengths, plus caliphered to determine percent body fat.

Subsequent sessions will be scheduled to collect information about the subjects' ability to perform the military tasks, upper and lower body strength and edurance. The specific military tasks under investigation are:

1) Low High Crawl, first crawling low, with all body parts close to the ground for 30 m, then high, on hands and knees for 45 m carrying a simulated rifle;

2) Land Stretcher Carry with a load of 80 kg:
   a) over flat ground for a distance of 1 km;
   b) up and down a flight of stairs.

3) Sea Stretcher Evacuation carrying a load of 80 Kg:
   a) 12.5 m over the (simulated) lower deck of a ship;
   b) up a flight of stairs to the upper deck, then returning;
   c) 12.5 m back along the lower deck to the original starting point.

4) Foxhole Dig in which subjects will be asked to dig a (simulated) foxhole;

5) Sand Bag Carry in which subjects will be asked to carry as many 50 lb sandbags as possible a distance of 50 m in a ten minute time period.

During these tasks, heart rate and other cardiovascular or muscle strength and endurance measures will be monitored by means of standard laboratory techniques.

In addition to the specific military tasks, overall upper and lower body muscular strength and endurance will be assessed by requiring subjects to perform standardized tests using ILM, arm ergometer, leg ergometer, grip dynamometer, bench press and other simple tests that may simulate the military tasks. During these tests, standard physiological and biomechanical data such as heart rate, oxygen consumption or filming of these events may occur.

Subjects Benefits

The subjects will receive, in addition to the satisfaction of helping to answer the question at hand, a profile of his/her strength and endurance capabilities.

Subject Risk and Discomfort

Subject safety and comfort will be a foremost consideration. Safety equipment (eg., safety ropes, gloves) and personnel will be in place for all tasks in order to maximize safety and minimize risk of injury. In addition, a recovery period of one day will be provided for the very stressful activities (eg., stretcher carry). Although it is conceivable that subjects may experience a strained muscle during performance of these tasks, the warm-up routine that will be provided reduces the liklihood of this occuring. However, if a subject feels any task is too demanding, the task may be terminated at any time without coercion from the investigator.

Each subject is welcome to discuss the protocol and outcome of their tests with the principal investigator, Dr. Joan Stevenson, or the Acting Director of the School of Physical and Health Education, Dr. Don Macintosh, on any matter pertaining to the study.

Thank-you for your consideration of our study. If you require any additional information, please do not hesitate to contact:

Sheryl French
or
Dr. Joan Stevenson
School of Physical and Health Education,
Physical Education Centre,
Queen's University,
Kingston, Ontario.
Phone: 545-2658

School of Physical and Health Education

Queen's University

Minimum Physical Fitness Standards Study: Phase II

Subject Consent Form

I,__________________________, having had the study explained to me verbally and in writing, am voluntarily participating in the "MPFS Study" being conducted by Dr. Joan Stevenson in the Fitness Centre and Biomechanics Lab at Queen's University.

I understand that any personal information obtained will be held in confidence. This information may be used for scientific purposes, but will not be revealed in any way in which I may be identified as a participant.

I understand that I may withdraw from this study at any time and for any reason. If I have any questions or complaints about this study, I may contact Dr. Joan Stevenson, School of Physical and Health Education. If I am not satisfied with this process, I may contact Dr. D. Macintosh, Acting Director of the School of Physical and Health Education.

____________________ Witness

____________________ Signature

____________________ Date

____________________ Date

School of Physical and Health Education
Queen's University

ETHICS REVIEW PROCEDURE

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

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

TITLE AND PURPOSE OF PROJECT: Development of Minimum Physical Fitness Standards for the Canadian Armed Forces: Phase II

BRIEF DESCRIPTION OF PROJECT: This study will further investigate the fitness components involved in performing a series of military tasks.

DESCRIPTION AND SELECTION OF SUBJECTS: Subjects will be 100 male and 100 female Canadian Forces personnel who are between the ages of 20 and 49 years and in good health.

NATURE OF TESTS EMPLOYED: The tests performed will include a) anthropometry; b) military tasks; c) upper lower body muscular strength and endurance.

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: ______

Signature of Researcher

SCHOOL OF PHYSICAL AND HEALTH EDUCATION

Queen's University
Kingston, Canada
K7L 3N6

26 May, 1986

Major Earle Morris,
National Defence Headquarters,
Ottawa, Canada
K1A 0K2

Dear Major Morris:

We wish to identify several concerns that we have for the safety of the military personnel who will be tested to perform the minimal physical fitness tasks; in particular, we are concerned about the safety of subjects over 35 years of age. The American College of Sports Medicine in their handbook Guidelines for Graded Exercise Testing and Exercise Prescription (2nd Edition) stress that for persons 35 years of age and older the upper limit of work intensity that should be sustained for any length of time is equivalent to 90% of their heart rate reserve (pp. 39-41). We strongly concur and support that persons $\geq$ 35 years should not be involved in physical activity which forces their heart rates above this maximal limit, particularly without having direct EKG printout on each of these subjects during testing and an attending physician to diagnose any untoward signs. Although most subjects would be in no physical danger, the standards are designed to protect both subjects and researchers from unnecessary risk.

With these facts in mind, our Ergonomics Research Laboratory has decided to require all subjects over 35 years of age to wear a heart rate monitor which will be preset to give an audible sound when the heart rate exceeds 90% of an age-adjusted maximal; if this monitor indicates heart rates in excess of that value that test shall be stopped immediately with no opportunity provided to continue. Subjects will be notified of this safety precaution and encouraged to execute the task without undue concern.

In addition to heart rate monitoring, all subjects will be taught a suitable warm-up and cool-down routine prior to and after each test, and required to wear all possible safety equipment necessary for any task (such as weight-belts at lifting Stations, weight-belt and gloves at carrying Stations, knee and elbow guards and gloves at the Crawl Stations, and so on). Detailed verbal explanation, task demonstration, and actual practice (requiring only mild-to-moderate physical exertion on the part of the subject) will be provided at each task Station; as well, a written explanation of each task and protocol will be made available to subjects at test Stations should they so desire additional information. Specifically stated into each preamble by our test personnel will be the statement that should the subject wish to discontinue that particular task at any point he/or she should feel free to do so immediately. As well, all minor safety features such as bactin ointment, bandages, sun screen ointment, etc. will be provided by our research group.

We are aware that you have taken safety precautions at each test site and we encourage you to document these procedures to us so that all possible risks for subject safety are considered. Thank you for your assistance.

Yours truly,

Joan Stevenson,
Assistant Professor

JS/dd

cc: S. Myles
J. Thomson
T. Bryant
G. Andrew

APPENDIX C

DETAILED TASK METHODOLOGIES

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 (nor 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 must have the option to terminate any activity when he/she wishes, or feels it necessary.

Test Phase

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 will be stopped immediately 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.

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.

PREPARING THE BODY FOR TESTING

Warm-up Procedure

The purpose of a warm-up is to prepare the body for strenuous exercise by activating the respiratory and circulatory systems and stretching the muscles and connective tissue. A proper warm-up reduces the risk of injury to the participant.

The formal warm-up should be commenced 10-15 minutes prior to testing. The participant should stretch and jog lightly until their testing time.

1. Cardiovascular Warm-up

Each participant should jog slowly around a track or on the spot for 3-5 minutes. This exercise should leave the subject breathing noticeably (but not gasping heavily) and increase body temperature slightly. The participant should allow him/herself a short rest period of walking following the cardiovascular warm-up to recover and prepare to engage in the stretching exercises outlined below.

2. Stretching Warm-up

A few words of caution and tips on stretching exercises are necessary.

i) The participant should not overstretch or strain any muscle group by exceeding the inherent flexibility limitations of the particular joint, surrounding fascia and muscle being stretched.

ii) The participant should not apply stretching force by bouncing and jerking.

iii) The participant should slowly and smoothly increase the force of the stretch until the position is slightly uncomfortable. This position should be held for 5-10 seconds and repeated 3-4 times.

iv) The participant should progress through the stretching exercises from upper to lower body as outlined below.

AREA OF BODY		EXERCISE DESCRIPTION
Neck	a)	Interlock fingers behind the head. Gradually press down and hold.
Shoulders	a)	Slowly move the arms in circular (windmill) patterns both forward and backward, gradually increasing the circumference of the circle. Alternately, pull the arms down and through: first, one arm reaching out in front, pull down and through the hip and swing up behind, then the other and repeat.
	b)	Sitting with knees bent and arms behind seat, slide seat to heel and slowly swing knees from side to side.

	c)	Kneeling on hands and knees lower the shoulder joints to the floor and hold.
Trunk	a)	With the feet slightly apart and arms raised above shoulder height, flex the trunk laterally in both directions.
	b)	In the above position move the trunk in a large circular pattern in both directions.
Posterior Thigh	a)	Standing in stride position, hips squared and knees straight lower the head to the forward knee.
	b)	In the hurdler's position with the ankle flexed lower head to the straight knee.
Anterior Thigh	a)	Standing on one foot, gently pull the heel of the other foot to the seat.
Medial Hip	a)	Standing with legs wide apart, feet forward and hands on hips, bend the left leg and move the bodyweight to the left. Then shift to the right and repeat the action in that direction.
	b)	Sitting in the straddle position, gradually lower the head to between the legs (allowing the knees to come off the floor if they have to) while trying to keep the back flat.
Calves	a)	In stride position with the hips squared, flex the forward knee and gradually lean forward. The heels should remain flat on the floor with toes pointing straight ahead but do not force the heels to the floor.

The following tasks demand upper body lifting be done: ILM, Entrenchment Dig, Sandbag Carry, and Sea and Land Stretcher Carries. Emphasis should be placed on warming-up the shoulders and trunk in preparation for the actions employed in these tasks.

The following tasks are demanding on the legs: Sea and Land Evacuation Tasks, leg ergometer, and Sand Bag Carry. Emphasis should be placed on warming-up the posterior and anterior thigh and calves.

Cool Down Procedure

The purpose of a cool down following strenuous exercise is to gradually return the body to its resting state. A proper cool down is equal in importance to a proper warm-up. To cool down properly the participant should walk around the test site immediately after task completion until he/she feels sufficiently recovered (i.e., until the heart rate returns to $\leq$ 120 Bpm). This should take approximately 7-10 minutes.

QUEEN'S STATION

Incremental Lifting Machine

Introduction

This task requires performance of a series of lifts on an Incremental Lifting Machine (ILM). Weight is increased incrementally after each lift to determine an individual's maximum weight lifting capacity from floor to five and six feet.

Equipment Required

- ILM
- Displacement/Velocity (D/V) gauge
- 2 C-clamps with rubber stoppers
- 4 colored magnets (with lines)
- personal computer with Analog to Digital (A-D) converter and A-D control box
- 2 boxes "floppy disks"
- stop watch, tape measure, calculator

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 x and y displacement inputs of the D/V gauge will be connected to channels 1 and 2 respectively, of the control box. These two channels are 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 is preceded by a stretching warm-up which includes exercises for the muscles of the neck, arms, lower back and hamstrings.

Overview of Test Procedure

Prior to testing, the participant's hip and shoulder height (no shoes) and body mass must be determined. The predicted maximal ILM score is then calculated from body mass as follows:

women - 0.24 x weight(kg) + 11.2[illegible] = predicted ILM max score
men - 0.07 x weight(kg) + 43.[illegible] 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; thus the starting masses for men and women are 25 kg or 12.5 kg below the predicted maximum.

Subjects will perform a series of lifts to 6 feet, and upon failure will continue to the next ILM weight setting, attempting a 5 foot lift.

Each subject will perform three practice lifts in order tc acquire proper lifting technique. Lifting instructions (as outlined later in this protocol) will be read to the subject prior to his first practice trial, followed by a demonstration of the lift by the tester. The lift weights for the practice trials are determined as follows:

Practice 1:

PRACTICE LIFT WEIGHT = weight of armature (10 kg)

Practice 2:

$$\text{PRACTICE LIFT WEIGHT} = \frac{\text{starting weight}}{2} \pm 5 \text{ kg}$$

Practice 3:

PRACTICE LIFT WEIGHT = starting weight - 1 increment

Thus, for a man with a starting weight of 40 kg, the masses for the practice trials would be 10, 20 and 35 kg respectively.

Personnel will also be asked to use the Borg scale to rate the difficulty of each practice and the first test lift.

A rest period of 30 seconds must be taken between each lift. During the practice phase, corrections in the subject's lifting technique may be made by the tester (according to the lifting checklist found later in this protocol).

Data Collection

Data will be collected on the computer for each of the "practice" and "test" trials. Each trial will be identified by the subject's identification number (i.e., s222) which will be followed by a "p" in the "practice" situation. Data will also be recorded manually (see sample summary sheet).

Instructions to Subjects

The tester will read the following to the subject group:

1. The purpose of this test is to determine the maximum weight that you can lift to heights of 6 and 5 feet on the ILM.
2. You will position your feet at a comfortable distance from the handles, about shoulder width apart. The handles will be grasped palms down.
3. To start, have your arms straight, your back straight, your knees bent, and your neck hyper-extended (bulled).
4. The tester will say "Begin Lifting". You will then lift the bar by first extending your knees and hips, then using your

upper body to complete the lift. Use your legs to explode into the lift.

5. You must lift the armature in one continuous motion to the target height (as identified by the yellow magnet). Failure to comply with either stipulation will be recorded by the computer as a failed lift.

6. There will be a 30 second rest period between trials.

7. You will be allowed 3 practice trials. The first with the armature alone, the second with a weight of ___ kg, and the third at a weight of ___ kg.

8. After each practice lift and the first test lift, you will be asked to rate the difficulty of that lift. The Borg scale (tester will hold it up for subject to examine) matches numbers to words which describe the difficulty of the task. Choose the appropriate number.

9. You will start your test at a weight of ____ kg which will be incremented by 5 (2.5) kg after each successful lift.

10. Once you have failed at 6 feet, you will move to the next trial where you will lift the bar to a height of 5 feet. You will continue until you fail at 5 feet.

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

12. Are there any questions?

Lifting Checklist

Keep the back as straight as possible and the neck bulled.

During the initial phase of the lift, do not jerk the weight upward.

Leaning backward or arching forward are not acceptable lifting techniques.

The subject may stop at any time if he/she feels unable to lift the next weight.

Sample Data Sheet

SUBJECT NUMBER: s222
NAME: John Smith

TRIAL #	TYPE	COMPUTER ID	WT.	STATUS
1	PRACTICE LIFT	A01S22P.DAT	10	PASSED
2	"	A02S22P.DAT	30	PASSED
3	"	A03S22P.DAT	40	PASSED
1	FULL (183 CM)	A01S22.DAT	45	PASSED
2	"	A02S22.DAT	50	PASSED
3	"	A03S22.DAT	55	FAILED
4	"			
5	"			
6	"			
7	"			
1	FULL (153 CM)	B01S22.DAT	60	PASSED
2	"	BO2S22.DAT	65	FAILED
3	"			
1	COMPONENT	C01S22.DAT	45	PASSED
1	COMPONENT	D01S22.DAT	45	PASSED

NOTE: LIFT TYPES

A: BASE TO 183 CM
B: BASE TO 153 CM
C: BASE TO HIP........HIP HEIGHT_________CM
D: HIP TO SHOULDER....SHOULDER HEIGHT__________CM
E: SHOULDER TO 183 CM
F: EXTRA LIFT........__________ TO __________

QUEEN'S STATION

ILM Components

Introduction

This task requires that the subject performs one or more variations of the standard 183 cm. ILM lift.

Equipment Required

-see ILM protocol

Field Set-Up

-see ILM protocol

Protocol

Warm-Up and Cool Down

- see ILM protocol

Overview of Test Procedure

The tester should take measurements of the subject's hip and shoulder height (no shoes), prior to the test. Each subject will perform one practice at a weight of one increment below the subject's actual maximum ILM weight. If the subject has not performed the 183 cm test, then the predicted maximum score will be used as the actual maximum score. The subject will perform one lift for each specified component. The first component to be measured is the lift from shoulder to full extension. This is a type E lift. The second component will involve a lift from hip to full extension. This is lift type D. It should be noted that bending of the knees is not permitted for either lift. Data will be stored on the floppy disk as well as on the ILM data sheet.

LIFT TYPES

A: BASE TO 183 CM
B: BASE TO 153 CM
C: BASE TO HIP........HIP HEIGHT_________CM
D: HIP TO SHOULDER....SHOULDER HEIGHT__________CM
E: SHOULDER TO 183 CM
F: EXTRA LIFT........__________ TO __________

These heights will be entered into the computer program.

Data Collection

The tester will use the QILM program to collect data. Data will be collected for "test" trials only. Refer to the ILM protocol (i.e., Data Collection Sheet) for further details.

Instructions to Subjects

The tester will read the following to the subject:

1. You will position your feet at a comfortable distance from the handles, about shoulder width apart. The handles will be grasped palms down.

2. To start, have your arms straight, your back straight, your knees bent, and your neck hyper-extended (bulled). However, when the starting height of the handles is above your hips, you may not bend your knees.

3. The tester will say "Begin Lifting". You will then lift the bar.

4. You must lift the armature in one continuous motion to the target height (as identified by the yellow magnet). Failure to comply with either stipulation will be recorded by the computer as a failed lift.

5. There will be a 30 second rest period between trials.

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

7. Are there any questions?

QUEEN'S STATION

Wingate Test

Introduction

The Wingate test is a maximal performance test of an individual's anaerobic power. It requires an all out effort on a stationary cycle ergometer for 30 s. The subject must be highly motivated to determine his/her maximal score.

Equipment Required

- -Monark cycle ergometer
- -Monark arm ergometer
- -Commodore 64 microcomputer, printer, monitor
- -program cassette and tape recorder (plus an extra cassette)
- -co-axial cable with BNC connecter

Protocol

Warm-Up and Cool Down

The warm-up procedure for the ergometer tests will consist of 5 minutes of pedalling with a load of 40% of the predicted setting. The rate of pedalling will be determined by the subject. It is important that the subject be allowed a brief exposure to the arm ergometer at sub-maximal RPM's and workload. The warm-up will be followed by a 3 minute rest period before the test begins.

At the end of the test, the load is quickly reduced to minimum resistance and the subject continues to cycle at his/her own rate, or in the case of the arm ergometer, to cease cycling altogether but remain seated. The subject should be allowed to cycle until he/she feels recovered (ie. at least 2-3 minutes or until their heart rate has decreased to less than 120 beats/minute).

Data Collection

The computer will prompt the tester for relevant subject information as listed below. Type in the requested information, pressing the "RETURN" key after each input.

Name
Social Insurance Number (S.I.N.)
Workload: determined from the attached weight/workload table
Flywheel Circumference: 6 m for the cycle (leg) erg.
2.4 m for the arm erg.

The load will be applied within 4 seconds of the onset of cycling. When the predetermined load has been reached, the tester will press the "RETURN" key on the computer to start the 30 second test.

Instructions to Subjects

The tester will read the following to the subject group:

1. You must cycle as fast as possible for the entire test and not preserve strength or pace yourself. As well, you must remain seated throughout.
2. On the command "start", you will begin cycling at maximum speed.
3. Verbal encouragement will be given to help motivate you. The last 5 seconds of the test will be counted down as it appears on the screen.
4. The seat should be adjusted to a comfortable height on the cycle ergometer (knee in extended position approximately 15 degrees with toe clips utilized). A seat belt must be secured around the hips for arm ergometer testing.
5. If you feel this task is too demanding, it may be terminated at any time
6. Are there any questions?

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?

QUEEN'S STATION

Maximal Hand Grip Fatigue Test

Introduction

The maximal hand grip fatigue test is designed to determine the fatigue curve for maximum grip strength for each hand.

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 (handyno.com)

Field 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 "handyna". 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, SIN, group and hand being tested) as it is requested on the screen. In order to determine hand dominance, ask the questions listed under subject instructions below. The dominant hand is that which is used to perform the majority of the functions described.

At the start signal ('beep') the subject will pull as hard as possible. This will be used as a reference point for the fatigue curve in later trials. After a two minute rest, the fatigue trials will begin, again prompted by a 'beep'. A 10 s rest is given between each trial (recorded by computer). When the participant's grip strength falls below 85% of maximum, terminate the test by pressing the space bar. Repeat the test for the other hand.

Data Collection

Record the answers to the hand dominance questions beside the subject information on the print-out sheet. 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 for each trial, the original maximum grip strength, the grip strength for that trial and the latter expressed as a percentage of maximum.

Instructions to Subjects

The tester will read the following to the participant:

1. This test is a determination of your fatigue curve for your grip strength using a hand grip dynamometer. You are asked to complete the test, once for each hand. First, I would like to determine your hand dominance:

    1. Which hand do you use to write?
    2. Which hand do you use to brush your teeth?
    3. Which hand do you use to comb your hair?
    4. Which hand do you use to eat soup?
    5. Which hand do you use to throw a ball?

2. At the sound of the beep, squeeze the grip as hard as you can, then release. Your maximum grip will be shown on the screen.

3. After a two minute rest, at the sound of the tone, squeeze the grip again and release. A second tone will signal the end of the trial.

4. You will be given a 10 second rest, then, at the sound of the tone, sqeeze and release. This procedure will be repeated until your grip strength falls below 85% of your maximum grip strength. The entire preocedure will then be repeated with your other hand.

5. Are there any questions?

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 set-up for this test is identical to that of the Hand Grip Fatigue Test. 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, SIN, group and hand being tested) as it is requested on the screen. If hand dominance was not previously determined in the Hand Grip Fatigue Test, then 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. Otherwise, simply the record 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?

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)
- heart rate monitor
- 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

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

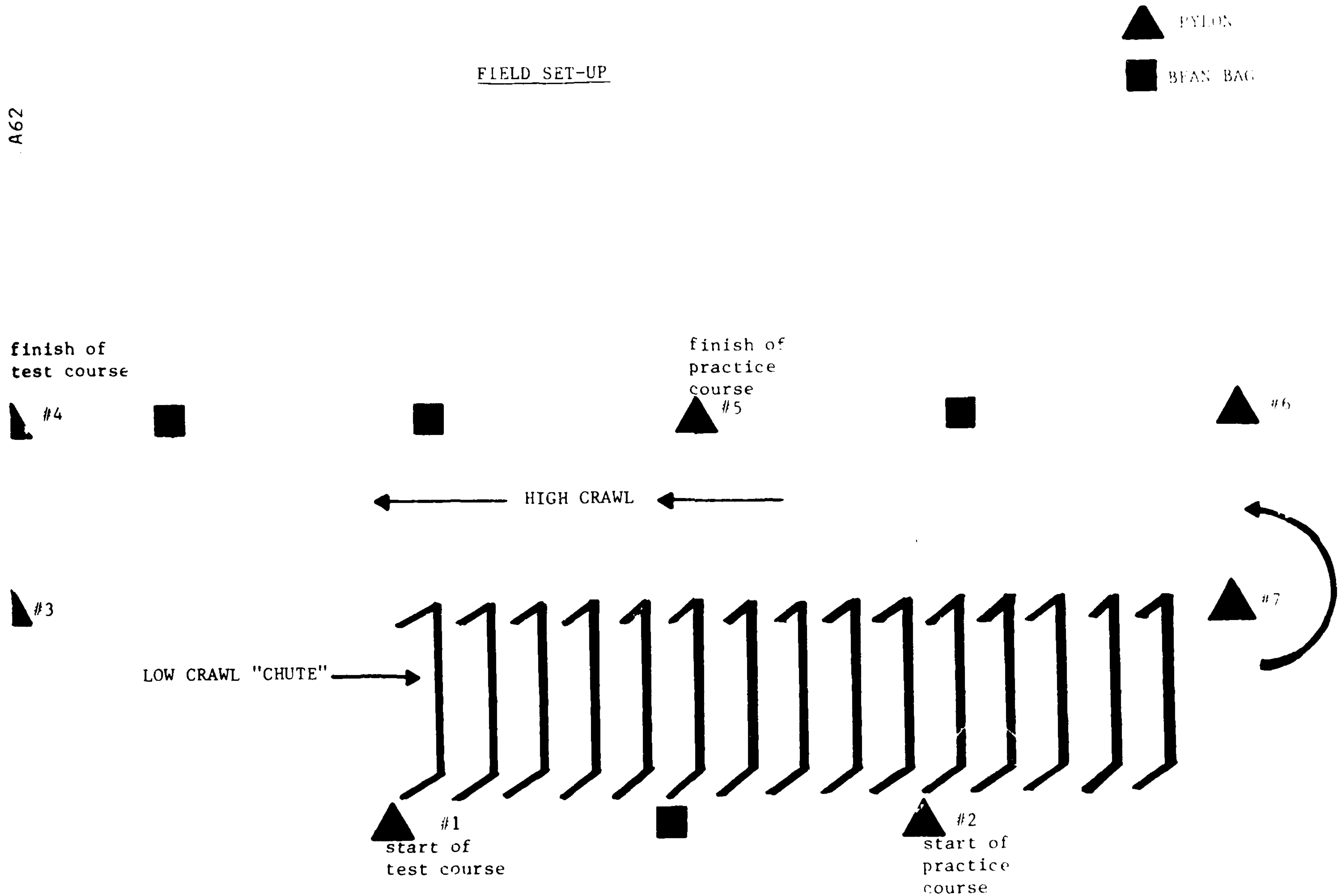
Warm-up and Cool Down

The task is preceded by a general cardiovascular and stretching warm-up and is followed by a cool down.

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

FIELD SET-UP


PYLON
BEAN BAG
finish of test course
#4
finish of practice course
#5
#6
HIGH CRAWL
#3
#7
LOW CRAWL "CHUTE"
#1
start of test course
#2
start of practice course

LOW HIGH CRAWL

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 10 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. 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
- -1 heart rate monitor
- -approximately 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)

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.

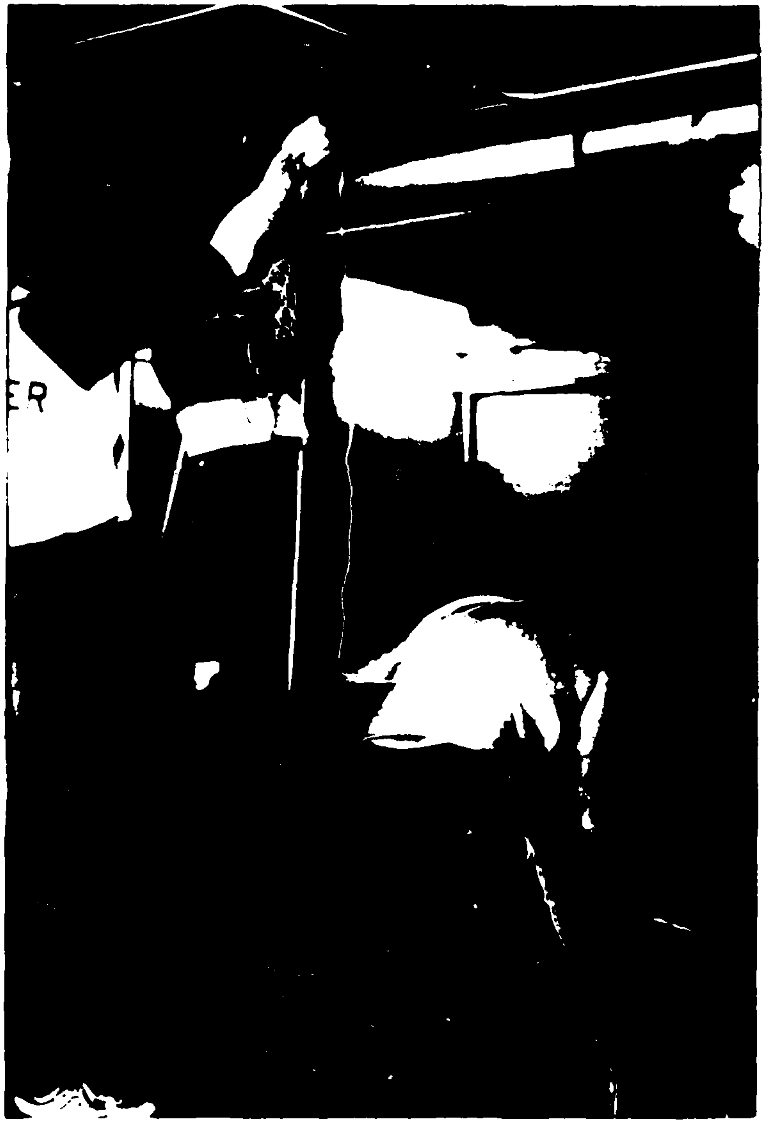
Protocol

Warm-up and Cool Down

The task is preceded by a general cardiovascular and stretching warm-up, and is followed by a cool-down.

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



ENTRENCHMENT (BOX - HOLE) DIG

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. Gloves will be provided, but you do not have to use them.
3. You will not be instructed on technique. You may use any digging technique which feels natural for you.
4. Standing inside, beside, or straddling the box to be cleared, you will start digging on the command "go".
5. You will clear the box, as fast a possible, pitching the crushed rock into the other box.
6. The test will end when you are given the command "stop".
7. 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.
8. Avoid excessive forward bending in order to reduce stress on the lower back.
9. Motivation will not be provided (by myself or other CF personnel). All persons other than Test Personnel will stay clear of the dig in the interest of safety.
10. If you feel this task is too demanding, it may be terminated at any time.
11. Are there any questions?

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
- stopwatch with memory
- strong nylon rope
- soft mats

Simulated Shipboard Set-Up

A simulation of a flight of stairs between two decks on a ship has been designed such that a Stoker stretcher, bearing the equivalent of an 80 kg person, can be moved up one deck, then back down, 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 a replica of the rear half of a Stoker stretcher. Free weights are securely affixed by means of a "pole and pin" device mounted into the bottom of this stretcher. 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; pulleys are attached to the crossbar above the 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 and Cool Down

The task is preceded by a general cardiovascular and stretching warm-up, and followed by a cool down.

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.

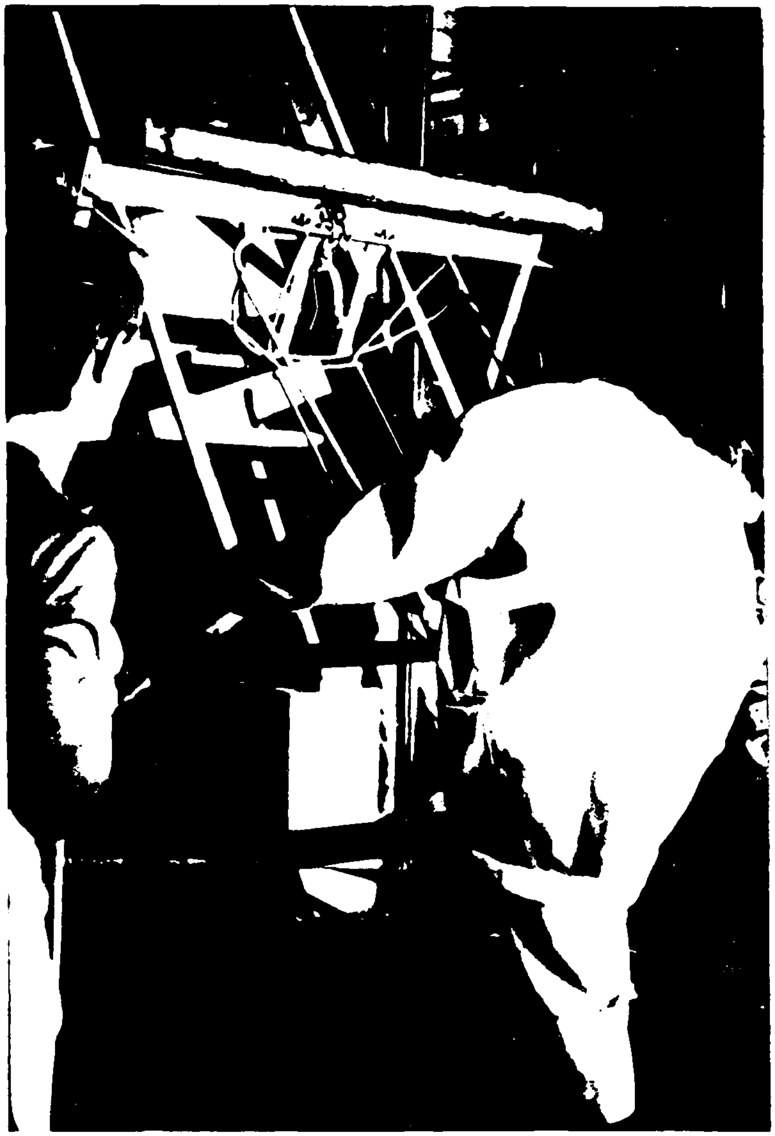
iii) time of stair descent: including any rest pause the subject requires while at the top, from the time the moveable apparatus contacts the stoppers at the top until the back wheels hit the stoppers at the bottom.

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 <u>rear</u> <u>end</u> 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 <u>simulated</u> 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.



(SIMULATED) SHIPBOARD EVACUATION

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.

<u>Lifting and Carrying Techniques "On Deck"</u>: 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.]

<u>Stair Carrying Position</u>: 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 se 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.]

<u>Stair Climbing Technique</u>: i) A "one-handed" technique may be used during the climb up and down the stairs: with the stretcher braced against your upper thighs (i.e., 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. If you feel this task is too demanding, it may be terminated at any time.

12. Are there any questions?

LAND EVACUATION

Introduction

The purpose of this task is to carry a loaded stretcher a distance of one kilometer as quickly as possible. This is a simulation of the evacuation of an injured person.

Equipment Required

- 2 stretchers with modified wheel attachments
- adjustable weights
- 2 stop watches
- 5 signs labled 250m, 500m, 750m, 1km, and start
- gloves, chalk, tape, 2 weight belts, water bottle
- meter wheel (used to measure track)
- 2 clipboards, pens, recording sheets

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 general cardiovascular and stretching warm-up and is followed by a cool down. Participants should particularly emphasize the wrist and forearm muscles in their warm-up exercises.

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 1 km 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 simulates an emergency rescue situation. You are carrying a seriously injured person, 1 km 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

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LAND STRETCHER EVACUATION

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

4. Are there any questions?

INCREMENTAL STRETCHER CARRY

Introduction

The purpose of this task is to determine the drop off in performance time of carrying a stretcher with incremental loads a distance of 250 m.

Equipment Required

- 2 stretchers with modified wheel attachments
- adjustable weights
- 2 stop watches
- 10 pylons
- gloves, chalk, tape, 2 weight belts, water bottle
- meter wheel (to measure track)
- 2 clipboards, pens, recording sheets

Field Set-up

The incremental task will take place, ideally, around a 250 m track. If unavailable a pylon will be placed at a distance of 250 m along a track.

Protocol

Warm-up and Cool Down

The test is preceded by a general cardiovascular and stretching warm-up and is followed by a cool-down. Participants should particularly emphasize the wrist and forearm muscles in their warm-up exercises.

Overview of Test Procedure

Each subject will complete four phases of the test. Each phase involves carrying a stretcher a distance of 250m. Phase 1 will employ an empty stretcher, phase 2 a stretcher with the equivalent of 40 kg, phase 3 the equivalent of 60 kg and phase 4 the equivalent of 80 kg. 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 of each phase will be recorded. In addition the number of drops will be recorded (see data collection sheet).

Instructions to Subjects

The tester will read the following to the subject group:

1. This task is designed to assist the investigators in determining if there is a significant drop off in your performance while carrying stretchers with varying loads. 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 wheelbarrow. Your arms, therefore, must remain relatively extended and straight.

2. You will wear a weight belt during phases 2,3 and 4 to give waist and back support. Gloves, chalk and tape are available to protect your hands.

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

4. Are there any questions?

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
- wheelbarrow
- 2 clipboards, pencils, recording sheets
- 2 pairs of gloves

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 general cardiovascular and stretching warm-up and is followed by a cool down. Both should emphasize the lower back area used in bending and lifting.

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, 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 carrying cycles (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 simulates 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. If you feel this task is too demanding, it may be terminated at any time.

6. Are there any questions?

APPENDIX D

RESULTS OF PRELIMINARY STUDIES (SPRING '86)

PILOT TESTING

Pilot testing was conducted in May - June, 1986 in preparation for the July mass testing. The goals of the pilot testing were as follows: 1) Train test personnel in protocols; 2) Test equipment and protocol modifications in terms of ease of administration, scheduling for mass testing, and to pinpoint any safety hazards with particular concern for over 35 year olds. To this end, input was obtained both from testors and participants and incorporated when possible; and 3) Obtain some test-retest data in order to make preliminary statements about the test-retest reliability of the task scores. Only results of the reliability study are reported.

Participants: A total of 60 men and women between the ages of 19 and 30 years, who were students from Queen's University participated in pilot studies. Of these, 18 men and 17 women were randomly assigned to the reliability group, and the remaining 25 were assigned to the "protocol" group (i.e., working with testing protocols and equipment).

Procedure: All participants were initially tested on EXPRESS tests. The first wave of testing included sessions for each of Queen's tests (flexed arm hang, arm and leg ergometers and endurance grip), and four military tasks, namely, Low High Crawl, Land Evacuation, Entrenchment Dig and Sandbag Carry. (The Sea Evacuation Task equipment was not completed in time to conduct test-retest evaluations before preparing to go to CFB Borden.) A rest period of at least one full day was imposed between test sessions. The second wave of testing (i.e., re-test) was conducted at least one week later. Only military tasks were repeated. However, several subjects were lost due to attrition thus the estimates for each of these four tasks are based on different samples.

Results: Summary scores for the EXPRES and laboratory tests are presented in Table AppD.1. Comparison of these values to that of the military sample (see section B) indicate that the two groups are comparable.

Task performance results are presented in Table AppD.2. Test values are presented first for all participants, and then for only those who completed the follow-up phase. The attrition rate is quite high, especially for women and the stretcher carry. However, it does not appear that this was a systemation loss of only the poor performers.

Low High Crawl

Thirteen men and seven women completed both the Low High Crawl sessions. Mean completio. times (in seconds) at test and follow up respectively for men were 79.9 (SD = 12.3) and 75.6 (SD = 13.7) respectively and for women were 129.0 (SD = 14.2) and 125.8 (SD = 12.7). Analysis of variance indicated a main effect of sex, ($F(1,19) = 76.3$, $p<.001$) but no effect practice ($F(1,20) = 2.90$ $p>.05$) and no interaction ($F(1,20) = 0.05$, $p>.05$)

Analyses were also completed for low crawl and high crawl completion times. For men, mean low crawl performance times at test and retest were 42.8 (SD = 7.4) and 41.3 (SD = 8.0) respectively. Mean completion times for women were 71.1 (SD = 13.4) and 70.2 (SD = 11.8) respectively. The high crawl was

Table AppD.1

Performance Scores for EXPRES and Queen's Laboratory tests by sex.

Test Variable	Women (n=17)		Men (n=18)	
	M	SD	M	SD
Weight	58.0	6.4	71.0	9.3
Height	158.[illegible]	26.5	177.8	7.6
VO_2 Max	40.3	3.4	51.5	5.2
Max Grip	57.4	6.0	99.3	16.9
Pushups	43.2	17.3	39.3	12.1
Situps	42.5	12.9	45.6	10.5
Flexed Arm Hang	28.9	15.9	49.2	12.9
Endurance Grip	130.6	76.1	288.6	117.1
Arm Ergometer Peak Power	809.1	168.5	1584.2	293.1
Leg Ergometer Peak Power	2537.0	395.5	3854.7	682.5

Table AppD.2

Military Task Performance scores at test and re-test by sex.

Military Task Variable		Women			Men		
		Initial Test	Test	Re-Test	Initial Test	Test	Re-Test
Land Stretcher Total Time	M	857.7	--	--	615.8	581.5	581.3
	SD	211.4	--	--	180.6	178.2	177.2
	N	.6	--	--	16	8	8
Crawl Total Time	M	123.2	129.0	125.8	78.7	79.9	75.6
	SD	16.3	14.2	12.7	11.8	12.3	13.7
	N	10	7	7	15	13	13
Low Crawl Time	M	68.6	71.1	70.2	42.2	42.8	41.3
	SD	12.2	13.4	11.8	7.1	7.4	8.0
	N	10	7	7	15	13	13
High Crawl Time	M	54.6	57.9	55.6	36.5	37.1	34.2
	SD	12.0	12.6	6.0	7.0	7.2	7.1
	N	10	7	7	15	13	13
Entrenchment Dig Total Time	M	524.2	558.4	460.4	238.9	227.9	224.4
	SD	220.8	269.6	187.6	60.1	53.0	50.6
	N	11	7	7	16	14	14
Sandbag Carry # of Bags	M	14.6	15.0	15.2	17.2	17.8	18.2
	SD	2.0	8	8	18	15	15
	N	12	8	8	18	15	15

completed somewhat faster at both test and follow-up by men (M_1 = 37.1, SD = 7.2;M_2 = 34.2, SD = 7.1 respectively) and women (M_1 = 57.9, SD = 12.6; M_2 = 55.6, SD = 6.0 respectively). Analysis of variance of low crawl data indicated a significant main effect of sex ($F(1,19) = 0.48.2$, $p<.001$) and a non-significant main effect of sex ($F(1,2C) = 0.50$, $p>.05$) and no sex by time interaction ($F(1,20) = 0.02$, $p>.05$). ANOVA for high crawl data provided similar results, that is a main effect of sex ($F(1,19) = 35.5$, $p<.001$) but not of time ($F(1,20) =36.1$, $p<.05$) nor an interaction ($F(1,20) = 0.04$, $p>.05$). Pearson correlation coefficients were calculated between test and retest scores for each of the three measurement variables. The resultant coefficients for total time, low time and high time were r =0.93, r =0.90 and r =0.89 respectively.

Land Stretcher

Only 8 men participated in both test (M = 581.5; SD = 178.2) and retest (M = 581.3, SD = 177.2) phases for this task. A repeated measures ANOVA indicated that there was not significant improvement (F <.01, $p>.05$). Pearson correlation resulted in a test-retest coefficient of r = 0.94).

Entrenchment Dig

Fourteen men and seven women completed both phases of the entrenchment dig. Comparisons of mean performance times at test and retest for both men (M = 227.5, SD = 53.0; M = 227.4, SD = 50.6 respectively) and women (M = 558.4, SD = 269.6; M = 460.4, SD = 187.6 respectively) suggests improvement over time (i.e., a pratice effect). An ANOVA indicated significant main effects of sex ($F(1,20) = 20.6$, $p<.001$), time ($F(1,21) = 10.2$; $p<.01$) and a significant sex by time interaction ($F(1,21) = 17.0$, $p<.001$). Women improved more at retest than their male counterparts. The test-retest Pearson correlation coefficient was, however, very high for this task ($r = 0.99$).

Sandbag Carry

A total of 23 participants (15 men and 8 women) completed this task at both times. Performance criteria for this task was total number of sandbags carried. Mean number of bags carried for males and females respectively at test was $M = 17.8$ (SD = 1.8) and $M = 15.0$ (SD = 23). Some improvement (i.e., more bags carried) was shown at retest ($M = 18.3$, SD = 2.0; $M = 15.2$, SD = 2.5 for men and women respectively). Analysis of variance indicated significant main effects of sex ($F(1,22) = 11.1$, $p<.01$) and time ($E(1,23) = 5.2$, $p < .05$) but no interaction ($F(1,23) = 0.50$, $p>.05$). The Pearson test-retest correlation coefficient for this task was 0.96.

Discussion

The attrition rate was quite high. Although this was not entirely unexpected given our sample and testing circumstances (i.e., students leaving for summer jobs) it is of some concern, especially for women and the stretcher carry. Indeed the samples are small for all tasks. Thus the obtained reliability estimates, all of which were of the order of 0.90 must be interpreted with caution. As expected, performance on all tasks was related to gender, men performing significantly better than their female couterparts. Significant improvement in performance was also noted for two tasks, sandbag carry and entrenchment dig. This may be related to test experience; that is knowledge of the most efficient way to carry a sandbag or to dig. If so, we should endeavor to provide more instruction to participants prior to testing.

APPENDIX E

1986 MPFS II RAW DATA

Expres Data

Subject Number	Base	Sex	Age	Age Level	Weight (kg)	Height (cm)	Predicted VO2 Max (ml/kg/min)	Combined Max Grip (kg)	Pushup (#)	Situp (#)
100	Borden	M	21	LT35	92	175	53	88	34	42
101	Borden	M	22	LT35	93	168	52	96	24	38
102	Borden	F		LT35	62	152	41	80	28	32
103	Borden	M		LT35	75	180	54	110	33	44
104	Borden	M	20	LT35	68	174	48	112	23	40
105	Borden	M	22	LT35	85		45	79	26	36
106	Borden	F		LT35				60		
107	Borden	F	18	LT35	47		42	55	30	28
108	Borden	M	18	LT35	77	173	55		22	44
120	Borden	F	24	LT35	63	168	35	71	32	29
121	Borden	F	23	LT35	60	158	37	76	40	46
122	Borden	M	18	LT35	56	175	51	111	44	45
123	Borden	M	18	LT35	70	175	58	102	31	54
124	Borden	F	21	LT35	59	173	39	48	30	30
125	Borden	M	19	LT35	85	180	53	108	26	27
126	Borden	M	23	LT35	92	180	47	114	35	56
127	Borden	F	26	LT35	55	163	40	58	36	34
128	Borden	F	22	LT35	60	171	33	59	19	
129	Borden	F	26	LT35	55	159	37		61	47
140	Borden	F		LT35						
141	Borden	F	23	LT35	58	163	35	45	29	33
142	Borden	M	22	LT35	70	168	48	109	30	33
143	Borden	M	21	LT35	87	183	47	81	19	41
144	Borden	M	20	LT35	66	172	57	97	41	44
145	Borden	M	25	LT35	76	170	53	95	21	23
146	Borden	F	19	LT35	88	170	37	66	26	36
147	Borden	M	22	LT35	66	178	49	103	36	71
148	Borden	M	21	LT35	81	185	47	109	26	33
160	Borden	F	22	LT35	62		38	58	50	47
161	Borden	M	19	LT35	64	165	48	74	45	32
162	Borden	M		LT35		180				
163	Borden	M	20	LT35	76	178	56	125	37	25
164	Borden	M	19	LT35	73	175	47	95	50	47
165	Borden	M	21	LT35	72	183	55	104	9	38
166	Borden	F	20	LT35	59	160	37	56	42	37
167	Borden	M	23	LT35	64	170	42	53	21	39
180	Borden	M		LT35		180		73		
181	Borden	M	18	LT35	62	170	49	91	33	50
182	Borden	M	18	LT35	65	182	46	98	31	38
183	Borden	F	26	LT35	52		39	52		
184	Borden	F	21	LT35	73	175	35	89	39	47
185	Borden	F	19	LT35	60	164	42	51	40	29
186	Borden	M	25	LT35	62		47	86	22	34
187	Borden	M	18	LT35	78		56	132	27	30
188	Borden	M	22	LT35	77	180	48	107	39	37
200	Borden	M	22	LT35	83	180	53	106	25	46
201	Borden	M	21	LT35	72	180	47	92	15	36
202	Borden	M		LT35	71	173	56	97	28	36
203	Borden	M		LT35	75	174	56	114		
204	Borden	M	19	LT35	63	172	48	75	19	38
205	Borden	F	18	LT35	61	165	42	58	30	31
206	Borden	M	21	LT35	58	178	50	86	33	25
207	Borden	M	23	LT35	91	188	50	105	35	37

Subject Number	Base	Sex	Age	Age Level	Weight (kg)	Height (cm)	Predicted VO2 Max (ml/kg/min)	Combined Max Grip (kg)	Pushup (#)	Situp (#)
208	Borden	M	19	LT35	80	182	46	97	26	28
220	Borden	M	22	LT35	69	193	49	115	59	40
221	Borden	M		LT35	69	168	57	101	26	38
222	Borden	M	21	LT35	72	168	47	71	33	31
223	Borden	M	20	LT35	79		47	93	31	31
224	Borden	M	22	LT35	60	164	52	87	28	22
225	Borden	F	23	LT35	65	175	36	78	30	31
226	Borden	F	21	LT35	61	170	39	59	40	30
227	Borden	F	24	LT35	77	160	31	31	21	26
228	Borden	F	22	LT35	57	175	37	52	26	25
229	Borden	M	17	LT35	70		48	103	41	35
240	Borden	M	22	LT35	05	195	43	130	34	29
241	Borden	M	19	LT35	74	184	45	76	24	38
242	Borden	F	19	LT35	62	166	41	49	28	36
243	Borden	F	27	LT35	61	168	41	57	50	51
244	Borden	M	23	LT35	74	172	46	93	29	35
245	Borden	M	18	LT35	72	184	48	103	25	21
246	Borden	M	20	LT35	90	183	43	118	41	36
247	Borden	M	18	LT35	71	182	48	115	31	40
248	Borden	M	18	LT35	69	176	56	83	15	33
249	Borden	M	18	LT35	75	180	48	82	30	27
250	Borden	F	18	LT35	58	160	41	66	44	36
300	Ottawa	F	20	LT35	63	156	40	56	30	33
301	Ottawa	F	23	LT35	58	156	41		40	41
302	Ottawa	F	24	LT35	70	168	35	64	25	36
303	Ottawa	F	25	LT35	48	156	40	41	40	43
304	Ottawa	F	26	LT35	57	158	37	49	35	60
305	Ottawa	M	33	LT35	77	176	56	101	33	37
306	Ottawa	M	35	GE35	79	166	44	114	40	45
307	Ottawa	M	38	GE35	65	173	44	88	35	38
308	Ottawa	M	34	LT35	06	178	37			30
309	Ottawa	M	39	GE35	87	175	44	116	35	49
310	Ottawa	F	38	GE35	63	174	38	63	20	38
311	Ottawa	F	32	LT35	77	158	34	50	26	29
312	Ottawa	M	47	GE35						
313	Ottawa	F	25	LT35	62	166	37	52	34	43
314	Ottawa	F	28	LT35	67	174	35	49	20	40
315	Ottawa	F	35	GE35	51	156	41	53	30	30
320	Ottawa	F	37	GE35	44	159	37	37	40	29
321	Ottawa	F	25	LT35	57	162	43	65	42	22
322	Ottawa	M	36	GE35	81	172	42	100	23	27
323	Ottawa	F	22	LT35	54	160	44	59	44	56
324	Ottawa	F	32	LT35	71	163	28	44	16	15
325	Ottawa	F	34	LT35	63	160	32	59	40	32
326	Ottawa	F	23	LT35	66	166	35	76	40	41
327	Ottawa	F	23	LT35	76	166	36	56	35	30
328	Ottawa	F	27	LT35	69	158	37	58	32	36
329	Ottawa	M	46	GE35	78	168	38	118	25	41
330	Ottawa	F	35	GE35	68	174	31	63	20	24
331	Ottawa	M	31	LT35	79	180	47	108	40	44
332	Ottawa	M	35	GE35	77	168	47	122	40	38
340	Ottawa	M	33	LT35	78	168	37	115	25	22
341	Ottawa	F	22	LT35	75	166	37	86	37	50
342	Ottawa	F	32	LT35	53	160	40	76	50	45
343	Ottawa	F	28	LT35	71	173	37	57	30	11
344	Ottawa	F	26	LT35	62	176	37	67	30	17

Subject Number	Base	Sex	Age	Age Level	Weight (kg)	Height (cm)	Predicted VO2 Max (ml/kg/min)	Combined Max Grip (kg)	Pushup (#)	Situp (#)
345	Ottawa	F	25	LT35	66	172	32	54	30	35
346	Ottawa	M	45	GE35	66	183	47	66	24	32
347	Ottawa	M	43	GE35	85	181	39	139	31	37
348	Ottawa	M	36	GE35	69	179	56	108	40	41
349	Ottawa	M	44	GE35	81	184	32	104	26	35
350	Ottawa	F	20	LT35	62	167	35	56	26	43
351	Ottawa	F	24	LT35	48	164	46	72	50	70
352	Ottawa	F	23	LT35	64	165	37	63	33	35
353	Ottawa	F	22	LT35	75	168	36	73	40	41
354	Ottawa	F	20	LT35						
355	Ottawa	F	28	LT35						
360	Ottawa	M	35	GE35	76	176	46	105	39	37
361	Ottawa	M	30	LT35	78	174	46	102	19	34
362	Ottawa	M	30	LT35	73	168	48	85	20	35
363	Ottawa	M	30	LT35	62	174	50	87	30	46
364	Ottawa	M	32	LT35	74	180	46	121	50	53
365	Ottawa	M	41	GE35	80	179	44	137	35	39
366	Ottawa	M	40	GE35	88	179	38	140	36	40
367	Ottawa	M	37	GE35	02	174	41	141	50	28
369	Ottawa	M	32	LT35	88	175	41	103	17	30
370	Ottawa	F	27	LT35	69	159	34	49	35	30
371	Ottawa	F	29	LT35						
372	Ottawa	F	25	LT35	60	161	33	67	42	36
373	Ottawa	F	21	LT35	74	160	31	59	15	21
374	Ottawa	F	24	LT35	75	170	37	60	44	42
380	Ottawa	F	22	LT35	87	169	31	63	26	17
381	Ottawa	F	23	LT35	52	161	42	60	30	22
382	Ottawa	M	37	GE35	90	181	38	115	15	25
383	Ottawa	M	38	GE35	68	175	39	86	30	36
384	Ottawa	M	40	GE35	78	182	41	130	40	44
385	Ottawa	F	23	LT35	46	154	39	56	28	31
386	Ottawa	F	24	LT35	71	172	34	79	47	42
387	Ottawa	F	37	GE35	62	162	35	61	15	28
388	Ottawa	M	46	GE35	68	177	40	108	30	30
389	Ottawa	M	38	GE35	61	176	46	130	30	28
390	Ottawa	M	31	LT35						
391	Ottawa	F	37	GE35	80	170	36	90	45	37
400	Ottawa	F	36	GE35	66	168	36	170	40	41
401	Ottawa	M	43	GE35	68	187	36	107	35	50
402	Ottawa	M	44	GE35	74	166	45	89	20	31
403	Ottawa	M	39	GE35	80	175	45	96	60	50
404	Ottawa	F	30	LT35	61	162	36	69	30	34
405	Ottawa	F	23	LT35	57	170	38	59	24	35
406	Ottawa	F	22	LT35	59	163	38	67	33	28
407	Ottawa	F	22	LT35	48	157	37	57	35	20
408	Ottawa	M	35	GE35	76	176	43	107	41	52
409	Ottawa	M	43	GE35	03	177	35	125	10	27
410	Ottawa	F	23	LT35	78	174	35	67	40	30
411	Ottawa	F	22	LT35	45	158	39	66	35	27
412	Ottawa	M	22	LT35	80	182	54	137	35	32
420	Ottawa	F	37	GE35	60	165	31	56	19	27
421	Ottawa	M	36	GE35	87	178	44	100	22	36
422	Ottawa	M	35	GE35	87	177	45	76	20	30
423	Ottawa	F	21	LT35	53	153	44	45	44	51
424	Ottawa	F	29	LT35	73	154	34	62	21	32
425	Ottawa	F	34	LT35	60	161	32	47	12	34

Subject Number	Base	Sex	Age	Age Level	Weight (kg)	Height (cm)	Predicted VO2 Max (ml/kg/min)	Combined Max Grip (kg)	Pushup (#)	Situp (#)
426	Ottawa	F	29	LT35	59	162	36	69	25	35
427	Ottawa	F	29	LT35	58	169	36	51	40	37
428	Ottawa	F	21	LT35	66	170	36	53	30	23
429	Ottawa	F	28	LT35	60	165	38	58	35	42
430	Ottawa	F	30	LT35	54	155	42	56	46	44
431	Ottawa	M	45	GE35	85	171	40	97	34	48
432	Ottawa	M	31	LT35	77	184	44	105	25	26
440	Ottawa	F	24	LT35	57	166	23	53	20	23
441	Ottawa	F	24	LT35	47	158	37	56	26	35
442	Ottawa	F	34	LT35	56	164	33	41	16	29
443	Ottawa	M	40	GE35	85	166	39	105	20	27
444	Ottawa	M	39	GE35	93	193	40	110	45	44
445	Ottawa	M	31	LT35	78	173	46	79	35	25
446	Ottawa	M	38	GE35	73	164	45	114	40	47
447	Ottawa	M	39	GE35	79	170	42	80	34	39
448	Ottawa	M	35	GE35	88	173	42	108	23	37
449	Ottawa	F	26	LT35	60	166	35	60	50	40
450	Ottawa	F	26	LT35	54	159	39	50	22	30
451	Ottawa	M	42	GE35	89	170	46	87	40	43
452	Ottawa	M	38	GE35	84	181	37	95	24	31
460	Ottawa	M	31	LT35	94	167	44	99	25	36
461	Ottawa	M	32	LT35	84	175	39	92	40	40
462	Ottawa	F	26	LT35	44	152	38	39	40	42
463	Ottawa	F	25	LT35	73	168	37	55	40	28
464	Ottawa	F	28	LT35	66	166	37		29	29
465	Ottawa	F	30	LT35	62	162	40	48	40	25
466	Ottawa	M	35	GE35	77	171	40	95	20	34
467	Ottawa	F	26	LT35	63	167	37		22	34
468	Ottawa	M	47	GE35	02	180	35	100	13	20
469	Ottawa	M	34	LT35	96	174	37	116	25	30
470	Ottawa	M	33	LT35	85	178	38	116	25	32
471	Ottawa	M	46	GE35	91	177	32	84	7	32
472	Ottawa	M	32	LT35	62	176	50	113	26	36
480	Ottawa	F	29	LT35	69	165	37	59	50	33
481	Ottawa	F	32	LT35	73	170	29	54	10	27
482	Ottawa	M	34	LT35	97	179	42	113	10	33
483	Ottawa	F	23	LT35	63	178	42	68	56	56
484	Ottawa	F	24	LT35	58	162	56	59	45	51
485	Ottawa	M	39	GE35	77	178	46	99	35	43
486	Ottawa	M	30	LT35	88	182	44	104	30	33
487	Ottawa	F	23	LT35	72	162	32	58	25	26
488	Ottawa	M	36	GE35	89	177	40	145	36	40
489	Ottawa	M	44	GE35	87	184	45	77	23	30
490	Ottawa	M	32	LT35	86	183	43	115	58	60

Queen's Laboratory Test Results

Subject Number	Flexed Arm Hang (s)	Endurance Grip (s)	Ilm Max Lift 183 cm (kg)	Ilm Max Lift 152 cm (kg)	Arm Ergometer Drop-off (%)	Arm Ergometer Work (J)	Arm Ergometer Peak Power (W)	Leg Ergometer Drop-off (%)	Leg Ergometer Work (J)	Leg Ergometer Peak Power (W)
100	39	52	60.0	60.0	47.1	8181.5	272.7	38.5	17599.1	704.0
101	30		60.0	60.0	38.9	10359.4	345.3	50.0	20836.4	988.8
102	31	56	27.5	27.5	42.9	3590.5	119.7	40.0	9515.7	388.5
103	23	56	60.0	65.0	52.9	8946.7	298.2	57.1	21542.8	1005.4
104	33	249	50.0	50.0	28.6	8475.8	282.5	38.5	21184.7	902.8
105	39	122	40.0	45.0	46.7	8358.1	278.6	57.1	19388.5	890.0
106	19	30	20.0	22.5	45.5	3551.2	118.4	30.0	11409.0	447.3
107	10	10	27.5	30.0	50.0	4022.1	134.1	33.3	9324.4	381.4
108	73	179	50.0	55.0	43.8	8230.6	274.4	46.1	19899.6	749.8
120	6	98	25.0	32.5	54.6	3428.6	114.3	33.3	10379.0	434.4
121	42	173	27.5	30.0	50.0	3825.9	127.5	40.0	10957.8	447.3
122	47							42.9	15823.5	692.3
123	53	151	45.0	50.0	41.2	7916.7	263.9	38.5	17093.9	673.3
124	16	15	20.0	20.0	40.0	3345.2	111.5	28.6	8054.0	313.1
125	28	364	55.0	60.0	42.9	7887.2	262.9	36.4	17481.4	699.3
126	39	114	45.0	55.0	62.5	6661.0	222.0	27.3	15279.1	569.8
127	19	81	17.5	25.0	40.0	3163.7	105.5	33.4	10016.0	392.1
128	4	74	20.0	22.5	44.4	2869.4	95.6	44.4	8946.7	402.5
129								38.5	12502.8	551.0
140										
141	25	41	25.0	25.0	29.9	3619.9	120.7	20.0	12301.7	447.3
142	62	135	40.0	45.0	47.0	8000.1	266.7	33.3	15892.2	635.7
143	27	160	45.0	50.0	52.9	8711.3	290.4	38.5	21096.4	857.1
144	50	181	50.0	50.0	28.6	7063.2	235.4	25.0	16314.0	593.3
145	15	163	35.0	40.0	46.7	7730.3	257.7	36.4	15308.5	660.4
146	9	32	30.0	40.0	50.0	4546.9	151.6	25.0	13184.6	527.5
147	60	266	50.0	55.0	44.4	7818.6	260.6	38.5	16314.0	673.3
148	37	124	50.0	55.0	44.4	9182.2	306.1	25.0	20341.0	762.9
160	22	41	30.0	30.0	27.3	4306.6	143.6	36.4	13272.9	530.9
161	49	141	40.0	45.0	28.6	6876.8	229.2	33.3	14832.7	593.3
162										
163	60	342	45.0	50.0	33.3	8652.4	288.4	38.5	18913.7	783.5
164	53	176	50.0	55.0	41.2	8662.2	288.7	38.5	18457.5	749.8
165	55	190	40.0	45.0	40.0	8122.7	270.8	33.3	17883.6	692.3
166	11	31	25.0	25.0	55.5	3487.5	116.2	54.6	10290.7	492.1
167	41	60	35.0	35.0	52.9	6778.7	226.0	53.9	14337.3	642.7
180	53	67	40.0	50.0	50.0	6611.9	220.4	46.2	14719.9	627.5
181	78	160	45.0	45.0	42.1	7897.1	263.2	53.9	14239.2	627.5
182	45	179	40.0	45.0	41.2	6886.6	229.6	46.1	14092.1	642.7
183		30								
184	11	67	30.0	32.5	45.4	4321.3	144.0	30.0	14106.8	553.3
185	26	57	25.0	25.0	40.0	3139.2	104.6	40.0	10290.7	447.3
186	86	133	30.0	35.0	35.7	5969.4	199.0	33.3	14719.9	579.1
187	57	359	45.0	50.0		7971.9	599.1	47.1	17971.9	860.5
188	47	154	60.0	60.0	47.1	8421.9	280.7	33.3	17712.0	720.4
200	41	106	55.0	60.0	52.0	8304.2	276.8	[illegible]	19512.0	840.6
201	43	107	50.0	50.0	53.3	6317.6	210.6	50.0	14352.0	649.7
202	37	117	35.0	40.0	58.8	6680.6	222.7	53.8	14567.9	688.7
203			35.0	40.0						
204	55	91	25.0	27.5	43.7	6337.3	211.2	41.7	14479.6	579.1
205	10	27	35.0	40.0	53.9	3688.6	123.0	50.0	12076.1	536.8
206	55	181	60.0	70.0	43.8	6013.5	200.5	38.5	13719.3	566.2
207	39	213	50.0	55.0	43.8	8593.6	286.5	57.1	20483.3	988.8

Subject Number	Flexed Arm Hang (s)	Endurance Grip (s)	Ilm Max Lift 183 cm (kg)	Ilm Max Lift 152 cm (kg)	Arm Ergometer Drop-off (%)	Arm Ergometer Work (J)	Arm Ergometer Peak Power (W)	Leg Ergometer Drop-off (%)	Leg Ergometer Work (J)	Leg Ergometer Peak Power (W)
208	36	135	50.0	55.0	52.9	7583.1	252.8	41.7	16726.1	692.3
220	69	374	60.0	65.0	41.2	7592.9	253.1	46.2	15362.5	688.7
221	53	44	50.0	50.0	47.1	7897.1	263.2	42.9	17746.3	741.6
222	59	53	45.0	45.0	50.0	7769.5	259.0	57.1	15431.1	758.1
223	21	89	40.0	40.0	40.0	8250.2	275.0	41.7	18246.6	7[illegible].3
224	46	229	35.0	35.0	42.9	5837.0	194.6	38.5	14312.8	581.6
225	27	126	25.0	22.5	40.0	4066.2	135.5	45.4	13557.4	634.4
226	24	67	32.5	32.5	42.9	4522.4	150.7	40.0	12242.9	470.9
227	1	35	22.5	22.5	50.0	3727.8	124.3	44.4	11826.0	519.1
228	3	37	17.5	20.0	45.4	3114.7	103.8	50.0	7838.2	423.8
229	47	184	50.0	55.0	50.0	8181.5	272.7	46.7	18683.1	812.3
240	31	65	40.0	80.0	47.1	9417.6	313.9	50.0	22979.9	1054.7
241	45	76	40.0	45.0	46.7	7098.5	236.6	44.5	11619.9	498.0
242	12	23	20.0	22.5	53.9	3742.5	124.8	54.5	11301.1	518.0
243	61	144	37.5	40.0	42.9	4507.7	150.3	36.4	12076.1	492.1
244	16	131	40.0	45.0	44.4	8475.8	282.5	38.5	18256.4	719.2
245	29	99	40.0	45.0	58.8	7357.5	245.3	57.1	15161.4	758.1
246	38	238	70.0	70.0	47.1	9064.4	302.1	41.7	21508.4	819.3
247	50	141	45.0	50.0	47.1	7391.8	246.4	50.0	18805.8	847.6
248	27	132	45.0	50.0	43.7	6759.1	225.3	50.0	16314.0	725.1
249	62	111	60.0	60.0	31.2	8367.9	278.9	42.9	18256.4	774.7
250	42	36	27.5	30.0	41.7	3889.7	129.7	50.0	11978.0	522.7
300	10	52	25.0	27.5	50.0	3369.4	113.0	40.0	11301.1	470.9
301	12	43	22.5	25.0	40.0	2967.5	98.9	30.0	11541.5	435.6
302	10	133	25.0	27.5	45.5	3958.3	131.9	40.0	11914.2	518.0
303	32	45	20.0	22.5	50.1	2815.5	93.8	30.0	9123.3	364.9
304	16	43	22.5	22.5	57.1	3624.8	120.8	40.0	9800.2	435.6
305	35	198	50.0	55.0						
306	45	283	45.0	55.0						
307	62	245	40.0	45.0						
308	11	167	35.0	45.0						
309	46	496	50.0	55.0						
310	22	229	25.0	25.0						
311	4	46	22.5	25.0	25.0	3938.7	131.3	44.4	12306.6	540.4
312	50	494	45.0	50.0						
313	12	88	22.5	27.5	50.1	3355.0	111.8	12.5	10859.7	386.2
314	7	50	22.5	25.0	30.0	3767.0	125.6	30.0	12360.6	494.4
315	48	72	25.0	25.0						
320	16	88	17.5	20.0						
321	19	83	15.0	25.0	30.1	3050.9	101.7	30.0	11232.5	423.8
322	31	277	50.0	55.0						
323	23	60	20.0	22.5	22.3	2879.2	96.0	50.0	10712.5	494.4
324	99	26	20.0	22.5	28.5	2864.5	95.5	44.5	10133.7	445.0
325	99	59	20.0	25.0	50.1	3139.2	104.6	42.8	8206.1	337.8
326	16	100	32.5	35.0	41.7	3992.7	133.1	27.3	14832.7	543.8
327	1	118	22.5	27.5	36.3	4703.9	156.8	54.5	12949.2	647.5
328	8	96	25.0	27.5	40.0	4203.6	140.1	45.5	13807.6	595.6
329	43	302	45.0	50.0						
330	9	231	20.0	22.5						
331	47	157	50.0	55.0	28.6	7735.2	257.8	25.0	17427.5	664.0
332	42	239	55.0	40.0						
340	5		35.0	35.0	62.5	7122.1	237.4	53.8	17[illegible]9.4	765.2
341	14	90	35.0	35.0	41.7	4792.2	159.7	45.5	14[illegible]5.0	647.5
342	18	29	12.5	30.0	36.4	3497.3	116.6	36.4	11865.2	466.1
343	4	210	17.5	20.0	54.6	3624.8	120.8	50.0	11644.5	541.5
344	3	24	22.5	25.0	50.0	3036.2	101.2	50.0	11536.6	470.9

Subject Number	Flexed Arm Hang (s)	Endurance Grip (s)	Ilm Max Lift 183 cm (kg)	Ilm Max Lift 152 cm (kg)	Arm Ergometer Drop-off (%)	Arm Ergometer Work (J)	Arm Ergometer Peak Power (W)	Leg Ergometer Drop-off (%)	Leg Ergometer Work (J)	Leg Ergometer Peak Power (W)
345	6	53	17.5	22.5	25.0	3109.8	103.7	45.5	11065.7	518.0
346	41	152	30.0	35.0						
347	59	577	45.0	50.0						
348	45	288	50.0	55.0						
349	22	265	50.0	50.0						
350	19	74	25.0	27.5	50.1	3428.6	114.3	45.5	11826.0	530.9
351	41	106	20.0	22.5	39.9	2884.1	96.1	22.2	8853.5	339.1
352	27	108	27.5	30.0	30.0	3919.1	130.6	45.5	12605.9	543.8
353	14	98	27.5	37.5	53.3	5488.7	183.0	41.7	16480.8	706.3
354	2	13	20.0	25.0	63.7	3791.6	126.4	37.5	11100.0	433.3
355	23	122	25.0	30.0	33.4	4027.0	134.2	36.4	12007.4	518.0
360	43	306	45.0	45.0						
361	30	171	45.0	50.0	53.3	7499.7	250.0	38.5	18011.2	780.5
362	37	114	55.0	60.0	64.7	7146.6	238.2	57.1	17015.4	807.5
363	58	77	35.0	40.0	50.0	5326.8	177.6	42.9	16652.5	675.7
364	00	349	50.0	55.0	40.0	7838.2	261.3	30.8	18256.4	719.2
365	67	333	45.0	50.0						
366	42	575	55.0	60.0						
367	40	275	60.0	65.0						
369	37	268	70.0	75.0	30.8	7887.2	262.9	41.7	19448.3	791.0
370	5	98	30.0	32.5	45.4	4203.6	140.1	44.4	11914.2	487.4
371	6	52	20.0	20.0	44.5	2835.1	94.5	40.0	10452.6	435.6
372	7	62	20.0	22.5	37.4	2938.1	97.9	36.4	12973.7	492.1
373	2									
374	6	63	27.5	32.5	30.0	4473.4	149.1	40.0	14106.8	600.4
380	1	86	22.5	35.0	54.6	4659.8	155.3	50.0	14832.7	706.3
381	4	38	12.5	20.0	37.4	2202.3	73.4	25.0	7720.5	301.3
382	12	171	45.0	45.0						
383	65	191	35.0	40.0						
384	47	248	65.0	65.0						
385	15	3	17.5	20.0	33.4	1451.9	48.4	40.0	7681.2	341.4
386	28	136	35.0	40.0	42.9	5125.7	170.9	33.4	15279.1	621.6
387		33	20.0	22.5						
388	44	190	35.0	35.0						
389	37	245	35.0	45.0						
390	50	437	55.0	70.0	52.9	8475.8	282.5	30.0	15892.2	635.7
391	18	215	25.0	27.5						
400	34	165	27.5	32.5						
401	43	245	35.0	40.0						
402	38	231	30.0	40.0						
403	50	224	60.0	65.0						
404	13	126	27.5	32.5	46.1	4027.0	134.2	45.4	10957.8	492.1
405	12	86	22.5	27.5	33.3	2898.9	96.6	20.0	11978.0	435.6
406	14	87	27.5	30.0	45.5	3207.9	106.9	45.4	10737.0	492.1
407	47	81	17.5	22.5	36.4	2923.4	97.4	53.9	10217.1	474.5
408	43	220	45.0	55.0						
409	12	344	45.0	50.0						
410	9	119	30.0	30.0	50.0	4831.4	161.0	33.3	14106.8	540.4
411	13	28	17.5	20.0	66.7	2074.8	69.2	57.1	9231.2	461.4
412	49	238	55.0	60.0	52.9	8073.6	269.1	56.3	19811.3	960.6
420	5		17.5	22.5						
421	34		40.0	45.0						
422	22		40.0	45.0						
423					50.1	3183.3	106.1	41.7	11742.6	494.4
424	0		20.0	20.0	63.6	3644.4	121.5	37.5	11340.4	442.6
425	5		20.0	20.0	50.0	3163.7	105.5	37.5	8711.3	348.4

Subject Number	Flexed Arm Hang (s)	Endurance Grip (s)	Ilm Max 183 cm (kg)	Lift 152 cm (kg)	Arm Ergometer Drop-off (%)	Arm Ergometer Work (J)	Arm Ergometer Peak Power (W)	Leg Ergometer Drop-off (%)	Leg Ergometer Work (J)	Leg Ergometer Peak Power (W)
426	4		25.0	25.0	38.5	4453.7	148.5	36.4	13032.6	530.9
427	14		45.0	45.0	58.4	3163.7	105.5	45.5	11104.9	479.1
428	8		22.5	25.0	64.3	3767.0	125.6	40.0	12306.6	482.7
429	34		25.0	27.5	42.9	4193.8	139.8	36.4	12291.9	466.1
430	40		22.5	27.5	43.7	4287.0	142.9	50.0	11124.5	494.4
431	32	171	50.0	55.0						
432	37		40.0	30.0	56.2	7347.7	244.9	30.0	15303.6	588.6
440	11	50	17.5	20.0	36.3	3619.9	120.7	53.8	11629.8	581.6
441	20	45	15.0	20.0	38.5	3389.4	113.0	50.0	9417.6	452.1
442										
443	20	306	40.0	45.0						
444	45	268	55.0	55.0						
445	39	181	35.0	40.0	30.8	7499.7	250.0	45.5	15009.3	660.4
446	54	234	30.0	40.0						
447	19	93	40.0	40.0						
448	27	126	50.0	55.0						
449	32	116	25.0	27.5	36.3	3757.2	125.2	36.4	12973.7	492.1
450	10	73	20.0	20.0	49.9	2987.1	99.6	54.5	9535.3	466.1
451	30	171	45.0	50.0						
452	30	230	30.0	50.0						
460		132	40.0	45.0	60.0	6827.8	227.6	44.4	15440.9	646.3
461	36	176	40.0	50.0	53.8	6474.6	215.8	30.0	16529.9	612.1
462	15	126	17.5	22.5	41.7	2668.3	88.9	45.4	8073.6	36[illegible].6
463	9	71	17.5	30.0	60.0	5228.7	174.3	50.0	15303.6	706.3
464	3		20.0	20.0	40.0	3541.4	118.0	44.5	10629.1	445.0
465	8	90	20.0	22.5	53.9	3742.5	124.8	40.0	10594.8	470.9
466	33	242	45.0	45.0						
467	15	74	22.5	25.0	45.5	3693.5	123.1	40.0	11369.8	494.4
468	20	195	60.0	65.0						
469	19	225	50.0	60.0	50.0	8122.7	270.8	50.0	19423.8	847.6
470	21	100	40.0	50.0	64.7	7887.2	262.9	36.4	17800.2	725.1
471	28	210	40.0	45.0						
472	58	188	45.0	45.0	37.5	6979.8	232.7	33.3	14126.4	565.1
480	9	102	27.5	27.5	53.8	4483.2	149.4	50.0	12723.6	541.5
481	4	40	17.5	20.0	55.5	3134.3	104.5	55.5	9957.2	498.0
482	12	245	40.0	50.0						
483	63	79	42.5	45.0	28.6	5474.0	182.5	25.0	15205.5	579.1
484	37	140	22.5	22.5	50.0	3825.9	127.5	45.5	11978.0	479.1
485	42	196	40.0	50.0						
486	29	170	45.0	55.0	50.0	7298.6	243.3	41.7	19119.7	819.3
487	3	13	20.0	22.5	54.6	4066.2	135.5	60.0	10290.7	541.5
488	39	408	50.0	55.0						
489	23	119	20.0	22.5						
490	35	233	50.0	55.0	46.7	8005.0	236.8	45.5	18364.3	777.0

Low-High Crawl Performance Times

Subject Number	Low Crawl Times 0m-10m (s)	10m-30m (s)	Total (s)	High Crawl Times 30m-50m (s)	50m-75m (s)	Total (s)	Total Time (s)
100	10	28	38	19	20	39	77
101	10	35	45	22	20	42	87
102	16	65	81	28	29	57	138
103	13	49	62	25	25	50	112
104	14	40	54	11	30	41	95
105	10	32	42	23	23	46	88
106	17	66	83	31	27	58	141
107	22	84	106	32	33	65	171
108	11	26	37	17	15	32	69
120							
121	31	74	105	34	29	63	168
122	19	54	73	27	25	52	125
123	8	18	26	17	17	34	60
124	18	101	119	3	28	31	150
125	12	25	37	18	16	34	71
126	9	28	37	20	20	40	77
127	19	58	77	33	27	60	137
128	20	53	73	34	30	64	137
129	24	55	79	34	24	58	137
140							
141	12	51	63	28	21	49	112
142	10	28	38	17	13	30	68
143	12	40	52	23	13	36	88
144	8	21	29	22	15	37	66
145	14	56	70	28	17	45	115
146	27	98	125	33	19	52	177
147	11	51	62	21	15	36	98
148	9	22	31	15	10	25	56
160	11	27	38	22	21	43	81
161	12	33	45	24	17	41	86
162							
163							
164	11	25	36	13	24	37	73
165	11	30	41	21	17	38	79
166	25	100	125	46	32	78	203
167	13	39	52	23	16	39	91
180	8	22	30	17	15	32	62
181	10	27	37	17	16	33	70
182	12	47	59	25	19	44	103
183							
184	16	32	48	24	27	51	99
185	20	78	98	41	41	82	180
186	13	38	51	25	17	42	93
187	11	30	41	20	22	42	83
188	9	28	37	19	17	36	73
200	12	44	56	21	18	39	95
201	11	40	51	20	17	37	88
202	21	68	89	30	29	59	148
203							
204	8	21	29	20	20	40	69
205	26	94	120	25	21	46	166
206	8	19	27	14	15	29	56
207	11	29	40	19	21	40	80

Subject Number	Low Crawl Times 0m-10m (s)	10m-30m (s)	Total (s)	High Crawl Times 30m-50m (s)	50m-75m (s)	Total (s)	Total Time (s)
208	10	31	41	19	19	38	79
220	8	22	30	16	15	31	61
221	15	41	56	19	20	39	95
222							
223	14	44	58	22	42	64	122
224	13	36	49	17	28	45	94
225	16	52	68	26	24	50	118
226	16	55	71	33	25	58	129
227	27	108	135	40	34	74	209
228	31	104	135	33	26	59	194
229	10	22	32	18	15	33	65
240							
241	13	34	47	22	23	45	92
242	13	57	70	26	26	52	122
243	11	27	38	18	17	35	73
244	11	34	45	24	22	46	91
245	9	25	34	18	18	36	70
246	8	20	28	18	20	38	66
247	8	25	33	16	18	34	67
248	12	36	48	24	25	49	97
249	9	25	34	20	20	40	74
250	15	46	61	22	26	48	109
300	15	52	67	34	29	63	130
301	18	50	68	30	28	58	126
302	20	58	78	29	25	54	132
303	19	47	66	34	27	61	127
304	13	41	54	25	26	51	105
305	13	35	48	16	33	49	97
306							
307							
308							
309	14	35	49	29	20	49	98
310	25	64	89	31	21	52	141
311	23	90	113	52	50	102	215
312							
313	20	53	73	32	26	58	131
314	20	52	72	31	28	59	131
315	21	50	71	36	24	60	131
320							
321	20	69	89	34	29	63	152
322	32	103	135	50	27	77	212
323	14	40	54	30	23	53	107
324	31	132	163	86	66	152	315
325	23	69	92	33	29	62	154
326	19	39	58	25	22	47	105
327	18	72	90	37	31	68	158
328	15	46	61	31	26	57	118
329							
330							
331	9	21	30	14	15	29	59
332	13	25	38	27	21	48	86
340	10	29	39	30	41	71	110
341	26	64	90	44	39	83	173
342	16	38	54	24	33	57	111
343	20	61	81	37	36	73	154
344	17	80	97	49	34	83	180

Subject Number	Low Crawl Times 0m-10m (s)	10m-30m (s)	Total (s)	High Crawl Times 30m-50m (s)	50m-75m (s)	Total (s)	Total Time (s)
345	17	47	64	35	30	65	129
346	15	42	57	26	83	109	166
347	14	31	45	20	18	38	83
348	11	24	35	21	19	40	75
349	22	49	71	29	22	51	122
350	13	36	49	29	25	54	103
351	22	53	75	28	27	55	130
352	14	57	71	26	28	54	125
353	13	41	54	33	22	55	109
354	23	80	103	31	36	67	170
355	11	30	41	27	29	56	97
360	14	37	51	12	30	42	93
361	13	38	51	24	22	46	97
362	11	34	45	22	23	45	90
363	11	32	43	25	23	48	91
364	8	18	26	14	13	27	53
365	16	32	48	27	23	50	98
366							
367	12	33	45	29	24	53	98
369	15	44	59	28	29	57	116
370	17	52	69	33	34	67	136
371	19	62	81	31	27	58	139
372	21	72	93	30	28	58	151
373							
374	22	57	79	31	26	57	136
380	27	85	112	34	33	67	179
381	20	79	99	33	29	62	161
382							
383	22	72	94	43	18	61	155
384	15	40	55	24	18	42	97
385	14	53	67	45	144	88	155
386	11	29	40	25	25	50	90
387	49	130	179	56	36	92	271
388	35	68	103	41	24	65	168
389							
390	8	21	29	20	19	39	68
391	24	60	84	38	26	64	148
400	19	56	75	34	32	66	141
401	18	42	60	30	29	59	119
402	16	38	54	31	27	58	112
403	7	19	26	13	17	30	56
404	16	36	52	24	26	50	102
405	15	48	63	27	24	51	114
406	17	46	63	32	30	62	125
407	12	39	51	26	20	46	97
408							
409	26	59	85	32	28	60	145
410	27	78	105	42	32	74	179
411	14	69	83	38	35	73	156
412	7	20	27	19	16	35	62
420							
421	16	36	52	31	26	57	109
422	18	43	61	34	33	67	128
423	20	59	79	21	25	46	125
424	25	83	108	47	40	87	195
425	55	55	110	34	34	68	178

Subject Number	Low Crawl Times 0m-10m (s)	Low Crawl Times 10m-30m (s)	Low Crawl Times Total (s)	High Crawl Times 30m-50m (s)	High Crawl Times 50m-75m (s)	High Crawl Times Total (s)	Total Time (s)
426	15	58	73	27	26	53	126
427	18	74	92	33	33	66	158
428	13	50	63	27	23	50	113
429	13	42	55	12	32	44	99
430	9	25	34	20	19	39	73
431	13	36	49	32	25	57	106
432	8	22	30	19	23	42	72
440	20	65	85	32	32	64	149
441	16	50	66	26	27	53	119
442							
443	11	31	42	22	21	43	85
444							
445	9	24	33	19	21	40	73
446	17	40	57	31	19	50	107
447	27	66	93	44	27	71	164
448	18	57	75	32	26	58	133
449	12	31	43	24	23	47	90
450	15	56	71	27	29	56	127
451	15	36	51	18	31	49	100
452							
460	11	31	42	25	25	50	92
461	12	29	41	20	20	40	81
462	15	39	54	21	21	42	96
463	11	42	53	27	47	74	127
464	23	79	102	43	31	74	176
465	21	61	82	34	33	67	149
466							
467	18	75	93	38	34	72	165
468							
469	17	48	65	32	26	58	123
470	12	32	44	25	25	50	94
471							
472	10	25	35	19	18	37	72
480	16	50	66	30	25	55	121
481	28	121	149	38	38	76	225
482	14	36	50	28	27	55	105
483	11	30	41	22	23	45	86
484	12	30	42	22	24	46	88
485	10	24	34	18	19	37	71
486	10	28	38	26	23	49	87
487	22	71	93	33	31	64	157
488	11	36	47	25	20	45	92
489	15	34	49	22	21	43	92
490	9	23	32	19	18	37	69

Land Stretcher Tasks Performance Times

Subject Number	Land Evacuation Task Times 0 - 250 m (s)	250-500m (s)	500-750m (s)	750m -1km (s)	Total Time (s)	Incremental Stretcher Times 1 0 kg (s)	2 40 kg (s)	3 60 kg (s)	4 80 kg (s)
100	100	130	137	116	483	61	90	99	155
101	75	165	114	98	452	57	64	73	84
102									
103	75	114	223	207	619	72	98	125	189
104	93	111	151	105	460	66	77	91	102
105	110	105	118	103	436	79	92	107	146
106	247	291	352	370	1260				
107	274	207	337	337	1155	153	194	270	345
108	88	103	144	113	448	72	85	95	145
120	226	248	286	260	1020	117	142	177	226
121	309	465	449	501	1724	98	129	192	193
122	198	272	231	287	988	74	90	116	144
123	130	171	201	499	1001	69	80	76	97
124	255	430	377	403	1465	100	155	202	233
125	103	133	135	129	500	63	72	73	86
126	151	286	211	263	911	78	104	98	132
127			299	284	1075	91	121	137	153
128	234	336	529	248	1347	116	159	208	259
129	204	247	643	573	1667	84	130	172	189
140									
141					1198	99	149	167	395
142	200	314	396	216	1126	61	77	97	155
143	156	242	265	326	989	67	87	108	116
144	160	210	216	203	789	58	67	76	148
145	192	276	276	273	1017	71	96	111	163
146	193	387	703	606	1889	105	103	133	246
147	129	178	143	187	637	67	85	104	106
148	127	36	328	217	708	56	68	78	87
160	293	440	503	390	1626	90	142	216	451
161	105	163	187	194	649	68	83	92	99
162	133	201	276	162	772	65	78	155	146
163	112	116	127	116	471	59	77	81	98
164	140	165	197	187	689	65	85	137	138
165	133	174	209	162	678	59	100	158	101
166			918	624	2754	145	256	670	291
167	135	417	437	363	1352	72	103	304	
180						69	105	114	242
181	156	145	252	185	738	69	88	110	122
182	212	278	257	233	98	61	98	136	138
183						117	163	183	297
184	225	291	310	291	1117	87	120	145	247
185	278	293	344	403	1318	117	160	228	303
186	162	239	281	190	872	60	106	112	136
187	160	184	153	161	658	65	85	100	108
188	170	214	195	161	740	65	83	97	105
200	170	152	252	205	779	61	74	77	114
201	142	255	316	274	987	77	85	87	120
202	174	209	273	224	880	97	95	103	139
203						77	105	159	154
204	177	234	245	180	836	75	108	110	231
205	234	321	307	275	1137	143	159	181	211
206	134	232	247	187	800	80	81	87	115
207	135	193	299	227	854	57	65	74	143

Subject Number	Land Evacuation Task Times					Incremental Stretcher Times			
	0 - 250 m (s)	250- 500m (s)	500- 750m (s)	750m -1km (s)	Total Time (s)	1 0 kg (s)	2 40 kg (s)	3 60 kg (s)	4 80 kg (s)
208	212	393	271	235	1111	71	86	100	132
220	126	133	131	137	527	59	74	80	93
221	201	297	282	300	1080	77	85	97	162
222	197	216	251	232	896	79	93	112	146
223	243	306	321	245	1115	93	115	134	295
224	184	229	296	265	974	86	105	138	280
225	153	185	212	170	720	91	105	115	126
226	171	209	238	229	847	90	158	160	189
227	516	814				183			
228	389	921				203	225	266	402
229	170	219	253	201	843	74	112	130	160
240	145	191	214	233	783	94	102	105	114
241	136	207	196	311	850	80	106	107	121
242	310	351	479	383	1523	105	136	215	229
243	145	209	182	220	756	87	106	103	130
244	191	259	285	346	1081	71	122	114	146
245	221	161	295	203	880	73	82	93	94
246	138	140	194	182	654	63	84	95	87
247	140	151	174	161	626	67	73	91	91
248	226	374	424	427	1451	97	128	139	321
249	177	224	377	470	1248	74	125	164	189
250	320	424	467	368	1579	97	133	201	267
300	192	251	315	235	993				
301	180	248	304	303	1035				
302	193	270			995				
303	207	424	517	493	1641				
304	212	265	365	287	1129				
305	135	225	240	222	822				
306	131	154	168	187	640				
307	148	207	215	204	774				
308	202	213	223	191	829				
309	124	137	152	140	553				
310	241	269	311	246	1067				
311	279	375	421	492	1567				
312	133	140	157	162	592				
313	167	177	277	209	830				
314	161	209	206	228	804				
315	160	208	184	195	747				
320	332	525	745						
321	269	352	374	366	1361				
322	183	195	231	192	801				
323	228	365							
324	243								
325	333	432	715						
326	158	235	265	271	929				
327	334	494	262	236	1326				
328	260	370	326	176	1132				
329	184	276	278	272	1010				
330	228	253	303	295	1079				
331	99	115	116	109	439				
332	232	229	204	191	856				
340	135	314	338	378	1165				
341	236	441	354	265	1296				
342	157	219	281	315	972				
343	263	327	346	294	1230				
344	366	454	585	485	1890				

Subject Number	Land Evacuation Task Times 0 - 250 m (s)	250-500m (s)	500-750m (s)	750m -1km (s)	Total Time (s)	Incremental Stretcher Times 1 0 kg (s)	2 40 kg (s)	3 60 kg (s)	4 80 kg (s)
345	205	338	347	401	1291				
346	121	169	117	190	597				
347	155	175	160	149	639				
348	114	114	125	149	502				
349	212	224	234	216	886				
350	177	297	358	284	1116				
351	360	330	325	332	1347				
352	180	317	238	226	961				
353	170	198	227	234	829				
354	208			291	1071				
355	177	221	235	278	911				
360	145	143	152	145	585				
361	158	102	205	222	687				
362	126	198	152	225	701				
363	190	230	377	295	1092				
364	109	95	91	84	379				
365	118	186			737				
366	166	170	198	193	727				
367	170	161	206	200	737				
369	137	219	224	288	868				
370	190	336	510	558	1594				
371	200	255	380	499	1334				
372	251	295	389	415	1350				
373	419								
374	178	222	201	258	859				
380	155	259	326	322	1062				
381	218	261	394	440	1313				
382	166	236	223	267	892				
383	221	243	254	192	910				
384	145	145	140	145	575				
385	345	429	636	110	2520				
386	168	220	215	182	785				
387	356	464	447	529	1796				
388	205	287	335	318	1145				
389	168	176	262	208	814				
390	85	110	118	108	421				
391	175	240	273	245	933				
400	155	305	275	296	1031				
401	195	187	248	150	780				
402	154	176	161	249	740				
403	83	117	122	122	444				
404	197	228	258	259	942				
405	234	315	348	431	1328				
406	249	326	433	302	1310				
407	215	229	184	338	966				
408	123	191	157	188	659				
409	186	288	310	242	1026				
410	141	180	362	222	905				
411	514	483	715						
412	124	146	190	165	625				
420	258	325	394	394	1371				
421	164	173	198	200	735				
422	136	171	208	200	715				
423									
424	192	226	282	278	978				
425	437	285	321	330	1373				

Subject Number	Land Evacuation Task Times 0 - 250 m (s)	250-500m (s)	500-750m (s)	750m-1km (s)	Total Time (s)	Incremental Stretcher Times 1 0 kg (s)	2 40 kg (s)	3 60 kg (s)	4 80 kg (s)
426	173	222	250	243	888				
427	188	226	261	231	906				
428	170	262	303	298	1033				
429	189	255	204	167	815				
430	148	197	229	248	822				
431	180	131	199	225	735				
432	135	189	184	168	676				
440	231	361	340	371	1303				
441	206	274	363	408	1251				
442	287	342	441	322	1392				
443	108	132	139	146	525				
444	141	149	166	164	620				
445	125	162	171	175	633				
446	163	192	240	237	832				
447	218	277	317	322	1134				
448	175	212	267	270	924				
449	194	242	296	282	1014				
450	262	400	456	411	1529				
451	130	135	137	162	564				
452	162	178	198	206	744				
460	136	168	236	174	714				
461	117	158	175	133	583				
462	236	365	411	349	1361				
463	119	220	364	305	1008				
464	252	286	290	370	1198				
465	201	233	325	341	1100				
466	216	236	275	233	960				
467	198	226	223	271	918				
468	154	195	300	261	910				
469	113	175	190	194	672				
470	154	156	189	147	646				
471	182	245	302	271	1000				
472	128	178	221	151	678				
480	209	253	314	292	1068				
481	204	311	314	359	1188				
482	163	226	253	315	957				
483	112	147	163	160	582				
484	158	163	166	201	688				
485	130	127	148	159	564				
486	163	151	138	173	625				
487	177	385	614						
488	135	133	154	198	620				
489	128	176	129	137	570				
490	128	140	202	141	611				

Sea Evacuation and Entrenchment Dig Performance Scores

Subject Number	Sea Evacuation Task Times To Stairs (s)	Up Stairs (s)	Down Stairs (s)	To End (s)	Total Time (s)	Entrenchment Dig Scores Dig Rate by Minute First (# shovels/second)	Middle	Last	Total Time (s)
100	5	14	13	9	41	16.8	12.5	5.5	241
101	6	12	8	11	37	13.8	10.8	5.8	201
102	7	110	35	23	175	10.0	7.8	4.8	478
103	5	19	16	11	51	14.8	8.3	4.8	247
104	5	14	11	10	40	15.3	12.8	6.8	201
105	6	18	9	11	44	11.8	11.3	4.0	208
106	7	31	24	12	74	12.3	5.0	4.3	603
107	999					8.8	3.8	2.5	913
108	7	10	8	9	34	13.3	11.5	8.0	193
120	11	124	60	19	214	14.8	8.5	5.5	413
121	999					9.5	6.5	4.0	503
122	8	20	19	12	59	8.0	8.8	6.0	306
123	6	12	10	11	39	13.3	10.3	5.5	230
124	999					9.3	7.3	3.8	500
125	6	11	8	8	33	15.0	13.3	6.3	203
126	7	17	12	9	45	16.3	12.3	6.8	267
127	10	130	117	20	277	10.8	8.3	6.0	443
128	999					11.3	7.5	4.5	481
129	11	74	50	15	150	10.8	9.5	6.5	354
140						9.3	6.3	3.8	
141	8	66	44	18	136	12.5	8.0	5.3	526
142	6	23	16	12	57	12.3	9.8	4.3	201
143	7	12	12	10	41	9.5	8.5	2.5	260
144	7	13	14	11	45	10.8	8.3	3.5	275
145	7	18	21	11	57	13.0	9.0	5.3	275
146	10	104	42	19	175	9.8	9.3	3.5	426
147	6	22	14	11	53	13.3	9.5	5.5	237
148	7	12	19	10	48	12.5	11.3	7.5	212
160	4	17	30	35	86	15.8	9.0	10.3	504
161	7	23	19	12	61	16.3	11.5	6.3	247
162	7	24	29	13	73				
163	7	11	14	12	44	14.0	10.5	5.3	212
164	6	17	8	10	41	13.8	10.0	5.3	264
165	6	15	11	10	42	13.3	9.8	7.3	217
166	8	81	92	22	203	8.5	4.0	3.0	784
167	7	21	18	11	57	10.5	5.0	5.0	436
180	999								
181	6	15	11	11	43	14.5	8.3	7.8	244
182	5	15	12	11	43	9.0	5.8	2.3	388
183	999								
184	8	42	22	13	85	14.5	8.3	3.8	448
185	999					12.0	8.8	3.8	554
186	7	20	24	12	63	20.5	10.5	6.8	202
187	6	12	11	11	40	12.3	10.0	3.5	272
188	5	13	12	11	41	18.5	11.3	6.5	231
200	5	12	13	6	36	14.8	9.5	5.0	219
201	5	22	19	10	56	13.0	8.8	6.0	263
202	6	17	11	10	44	11.0	9.0	6.5	363
203	999								
204	8	26	19	9	62	14.5	11.0	5.3	304
205	10	40	49	20	119	11.3	8.8	3.8	481
206	6	17	10	10	43	10.5	10.0	6.8	260
207	5	13	8	9	35	14.0	11.5	6.3	203

Subject Number	Sea Evacuation Task Times: To Stairs (s)	Up Stairs (s)	Down Stairs (s)	To End (s)	Total Time (s)	Entrenchment Dig Scores: Dig Rate by Minute (# shovels/second) First	Middle	Last	Total Time (s)
208	7	25	17	13	62	13.0	9.0	7.5	304
220	6	11	7	9	33	14.3	10.0	5.5	223
221	5	12	10	9	36	13.3	10.5	7.3	199
222	5	14	11	10	40	13.0	10.3	7.0	286
223	5	19	19	10	53	15.8	11.3	7.3	250
224	7	25	22	14	68	15.3	11.3	7.5	237
225	7	28	22	14	71	11.0	9.0	4.5	329
226	7	43	53	16	119	11.3	8.8	5.0	340
227	999					13.0	6.8	4.8	443
228	999					9.5	7.3	6.0	542
229	6	13	10	9	38	15.5	10.0	5.0	246
240	6	9	12	9	36	13.5	11.8	8.0	167
241	6	46	15	12	79	14.0	8.8	8.0	268
242	9	150	98	22	279	12.8	8.3	4.0	405
243	6	24	16	12	58	11.0	8.3	7.0	273
244	6	20	12	11	49	17.3	10.5	6.5	202
245	5	13	12	9	39	15.3	12.8	8.3	210
246	5	8	9	9	31	15.8	15.0	10.3	161
247	6	15	8	10	39	13.0	7.8	7.0	238
248	6	16	10	8	40	12.5	10.5	6.8	208
249	6	12	11	7	36	14.0	8.8	8.3	241
250	10	31	39	18	98	13.0	6.3	3.8	371
300	999					11.5	10.3	5.5	510
301	12	45	38	26	121	13.5	6.8	4.0	568
302	18	27	35	17	97	8.8	8.0	2.8	577
303	14	54	50	24	142	10.3	7.0	6.0	604
304	16	188	63	31	298	9.8	6.0	5.0	472
305	13	25	47	21	106	11.8	10.5	3.5	279
306	11	14	13	10	48	9.5	8.8	4.0	246
307	12	22	15	15	64	9.0	7.0	3.5	339
308	15	21	82	27	145	9.0	9.0	9.0	269
309	8	12	6	12	38	13.8	12.5	5.0	220
310	999					7.3	4.3	3.0	586
311	999					13.3	7.3	6.5	513
312	9	19	19	22	69	10.5	9.5	6.3	324
313	16	71	50	30	167	8.0	7.3	4.3	458
314	15	95	57	26	193	8.5	5.0	5.0	648
315	18	92	53	21	184	9.5	5.5	6.5	509
320	999					8.5	5.0	4.0	
321	999					12.8	9.0	4.8	477
322	14	44	25	15	98	10.0	8.5	5.0	340
323	11	255	34	22	322	12.5	6.0	4.0	600
324	14	101	48	39	202	9.0	5.3	3.0	905
325	12	225	75	33	345	8.0	6.0	4.0	586
326	10	26	17	15	68	7.5	7.3	3.5	405
327	12	22	22	18	74	16.3	11.3	5.7	537
328	9	143	44	19	215	13.7	7.8	4.3	445
329	999					13.8	6.3	4.0	448
330	999					12.0	11.0	2.8	504
331	5	9	7	7	28	12.5	11.0	6.5	227
332	10	22	22	24	78	6.5	4.7	4.8	450
340	10	24	21	17	72	8.3	7.3	3.0	336
341	12	77	54	20	163	8.3	6.0	2.0	645
342	10	51	21	20	102	11.5	8.8	4.8	420
343	999					12.0	9.5	5.5	529
344	13	50	61	21	145	9.5	4.5	2.3	647

Subject Number	Sea Evacuation Task Times					Entrenchment Dig Scores			
	To Stairs (s)	Up Stairs (s)	Down Stairs (s)	To End (s)	Total Time (s)	Dig Rate by Minute (# shovels/second) First	Middle	Last	Total Time (s)
345	13	218	56	27	314	10.3	5.0	4.5	789
346	13	18	26	19	76	12.5	9.5	3.0	335
347	14	34	18	19	85				476
348	9	15	12	19	55	15.5	13.3	6.5	352
349	999					10.8	5.5	4.5	690
350	10	35	17	17	79	12.5	6.0	4.3	592
351	15	145	61	29	250	11.0	6.0	4.3	620
352	7	16	16	14	53	9.8	6.5	3.8	418
353	7	18	14	14	53	11.5	9.5	6.3	335
354	10	33	46	22	111				459
355	9	48	25	17	99	10.0	9.0	2.3	430
360	10	22	18	14	64	10.3	7.3	5.5	349
361	10	16	14	14	54	9.5	8.8	7.0	262
362	11	112	77	29	229	16.0	8.0	11.0	249
363	8	15	17	15	55	11.3	8.0	6.3	314
364	10	11	9	11	41	20.3	12.8	7.5	233
365	7	14	8	10	39	7.0	9.3	9.0	246
366	8	11	8	12	39	11.0	8.3	6.0	246
367	8	15	7	15	45	9.0	8.8	5.0	251
369	9	19	12	14	54	11.5	11.0	7.0	325
370	13	137	87	50	287	10.3	8.0	5.0	512
371	9	13	10	15	47	10.8	5.5	5.3	447
372	11	58	32	23	124	10.3	7.8	4.8	507
373	999	999							
374	10	77	36	28	151	11.8	10.5	4.0	377
380	11	56	33	19	119	10.0	6.0	4.5	538
381	999	999				8.8	4.0	5.0	728
382	11	15	9	17	52	13.3	9.5	3.0	269
383	11	21	59	11	102	13.5	10.0	3.5	278
384	9	8	9	6	32	12.8	8.5	6.3	242
385	999	999							
386	7	16	7	11	41	11.3	8.3	5.3	372
387	999	999				9.5	6.3	5.0	687
388	13	19	12	62	106	9.0	5.5	4.5	442
389	20	30	65	27	142	9.5	8.3	2.7	423
390	4	6	5	6	21	18.3	11.0	7.0	174
391	12	19	66	14	111	10.8	10.0	7.3	364
400	9	15	13	16	53	9.8	5.5	4.0	538
401	12	19	90	18	139	7.5	4.3	4.8	459
402	12	18	19	18	67	7.3	6.8	6.7	299
403	4	8	6	8	26	9.3	11.8	3.5	239
404	10	121	21	20	172	7.3	7.0	5.0	431
405	10	25	28	15	78	10.3	5.8	3.8	575
406	11	26	29	17	83	8.3	3.0	4.0	620
407	8	38	35	16	97	11.3	9.0	4.8	472
408	8	11	5	11	35	5.8	4.8	3.3	473
409	10	32	133	15	190	8.3	3.3	3.0	450
410	7	27	24	18	76	10.0	6.3	7.5	403
411	999	999				12.3	5.3	5.0	631
412	4	13	2	11	30	12.8	8.0	4.0	278
420	999	999				4.3	4.0	3.0	944
421	8	11	8	12	39	11.0	7.3	2.8	285
422	8	17	8	18	51	11.8	9.5	14.5	263
423	999	999				16.3	7.3	6.5	492
424	13	59	55	19	146	5.3	5.3	3.7	557
425	13	122	13	31	179	3.8	6.0	5.5	993

Subject Number	Sea Evacuation Task Times: To Stairs (s)	Up Stairs (s)	Down Stairs (s)	To End (s)	Total Time (s)	Entrenchment Dig Scores: Dig Rate by Minute (# shovels/second) First	Middle	Last	Total Time (s)
426	7	25	19	15	66	14.5	9.8	5.3	445
427	9	363	55	19	446	5.5	4.0	5.5	576
428	11	74	62	17	164	12.8	7.8	6.0	431
429	9	37	17	16	79	13.0	10.5	4.8	383
430	5	16	12	13	46	10.5	8.0	5.8	437
431	6	12	103	13	134	10.3	8.3	3.8	268
432	7	10	7	10	34	12.5	8.8	2.8	263
440	17	338	48	33	436	9.5	7.0	4.8	473
441	9	360	24	19	412	7.5	6.0	4.6	533
442	999	999				12.0	7.5	6.3	553
443	6	13	11	10	40	11.3	10.5	7.8	217
444	8	12	9	9	38	12.8	7.8	6.3	309
445	9	11	9	14	43	13.0	6.3	2.5	293
446	10	11	78	10	109	9.5	6.5	4.0	347
447	10	53	25	20	108	6.0	7.0	4.5	534
448	7	15	12	11	45	7.0	6.0	3.8	429
449	7	24	26	14	71	8.3	7.5	4.3	493
450	9	236	69	36	350	12.5	7.0	4.0	
451	6	14	9	12	41	9.3	7.8	3.8	326
452	12	19	74	18	123	8.0	4.5	2.3	503
460	12	26	25	21	84	13.5	5.5	3.5	346
461	8	13	10	11	42	14.8	9.3	4.5	322
462	11	289	53	29	382	13.0	6.5	4.0	451
463	11	24	19	17	71	9.3	6.8	3.3	370
464	999	999				3.0	4.0	2.3	767
465	8	161	51	17	237	9.5	5.5	5.0	538
466	21	55	116	35	227	5.0	3.5	5.3	513
467	11	35	36	21	103	11.0	7.5	6.3	451
468	10	20	8	19	57	8.5	4.5	4.8	369
469	10	14	10	16	50	11.5	8.3	6.8	213
470	10	19	14	14	57	10.3	8.0	3.5	262
471	999	999				7.8	5.3	3.8	602
472	5	15	8	10	38	9.8	8.3	4.0	225
480	8	26	20	16	70	11.5	7.5	5.5	369
481	999					11.0	9.3	4.5	476
482	7	17	12	12	48	11.5	7.5	3.8	278
483	6	16	12	11	45	17.5	10.0	7.0	313
484	7	61	21	21	110	13.0	10.5	5.5	375
485	6	14	9	20	49	12.8	7.5	3.5	309
486	5	13	6	10	34	13.0	9.8	3.3	258
487	999					11.0	6.8	5.5	497
488	6	12	8	9	35	10.5	9.8	5.8	214
489	8	14	12	26	60	9.8	8.3	4.0	310
490	10	17	10	13	50	14.3	8.5	6.5	307

Sand-bag Carry Performance Scores

Subject Number	Total Sandbags Carried (#)	Overall Carry Rate (m/s)	Number of Bags Moved in: 1st min (#)	2nd min (#)	3rd min (#)
100	18.8	3.1	20	36	28
101	18.5	3.1	24	36	33
102					
103	15.4	2.6	27	41	32
104	18.7	3.1	30	33	30
105	17.1	2.9	35	34	37
106					
107	10.9	1.8	40	57	58
108	18.5	3.1	36	34	36
120	13.5	2.2	43	46	44
121	13.0	2.2	44	47	36
122	17.0	2.8	33	34	36
123	20.1	3.4	25	31	24
124	13.4	2.2	36	52	46
125	20.1	3.4	26	32	23
126	16.9	2.8	30	37	38
127	14.6	2.4	34	43	37
128	13.4	2.2	37	48	44
129					
140					
141	12.7	2.1	39	52	51
142	16.8	2.8	27	36	42
143	18.2	3.0	27	37	28
144	18.0	3.0	22	33	28
145	15.0	2.5	30	39	40
146	13.9	2.3	30	45	44
147	18.6	3.1	25	34	29
148	18.1	3.0	25	30	29
160	14.3	2.4	27	45	41
161	18.0	3.0	32	35	39
162	17.8	3.0	27	33	40
163	19.2	3.2	23	33	22
164	18.9	3.2	29	33	36
165	19.3	3.2	22	31	31
166	10.6	1.8	36	78	63
167					
180	13.8	2.3	36	51	49
181	16.6	2.8	30	39	34
182	16.2	2.7	30	35	32
183					
184	13.4	2.2	36	44	47
185	11.9	2.0	42	55	59
186	16.5	2.8	36	36	33
187	17.0	2.8	28	38	52
188	16.8	2.8	38	38	26
200	17.3	2.9	29	35	29
201	16.7	2.8	32	37	40
202	13.4	2.2	37	47	40
203					
204	17.0	2.8	27	35	43
205	13.4	2.2	36	52	41
206	18.7	3.1	30	33	32
207	17.1	2.9	33	38	30

Subject Number	Total Sandbags Carried (#)	Overall Carry Rate (m/s)	Number of Pags Moved in: 1st min (#)	2nd min (#)	3rd min (#)
208	16.9	2.8	27	36	35
220	20.7	3.5	26	31	31
221	17.1	2.9	29	36	38
222	17.8	3.0	30	33	25
223	14.7	2.5	30	37	46
224	16.1	2.7	37	38	39
225	14.5	2.4	42	41	41
226	14.5	2.4	38	39	39
227					
228	10.0	1.7	62	60	65
229	19.5	3.3	29	30	29
240	15.4	2.6	31	42	44
241	15.3	2.6	27	35	44
242	12.5	2.1	56	47	50
243	14.9	2.5	34	41	46
244	14.0	2.3	40	45	38
245	15.5	2.6	32	39	40
246	14.5	2.4	39	41	38
247	17.3	2.9	34	37	40
248	15.5	2.6	37	39	38
249	14.3	2.4	41	37	43

APPENDIX F

PARTICIPANT INFORMATION

A113

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

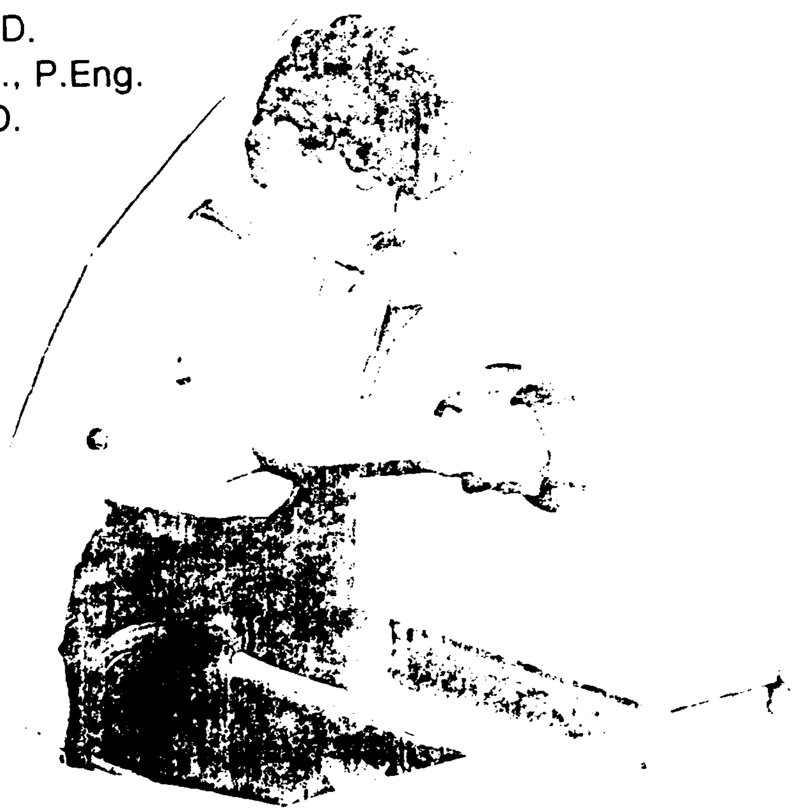
Development of Minimum Physical Fitness Standards for the Canadian Armed Forces

Participant Information
CFB Borden June 9-12, 1986

Joan M. Stevenson, Ph.D.
George M. Andrew, Ph.D.
J. Timothy Bryant, Ph.D., P.Eng.
John M. Thomson, Ph.D.

Research Assistants

Sheryl French
Leslie Langley
Jennifer Williams
Marcia Thomson
Chris van den Berg



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

MINIMUM PHYSICAL FITNESS STANDARDS STUDY: PHASE II

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards for all military personnel. The underlying principle 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, 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 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. 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:

i) for male CF personnel to assess (and improve where necessary) minimum physical fitness requirements for 30-39 and 40-49 year old personnel; and
ii) with female CF personnel, to identify and quantify those components of physical fitness involved in performance of these tasks.

The Ergonomics Research Laboratory has been contracted to conduct this study at CFB Borden the week of June 9, 1986, and CFB Ottawa the week following, commencing June 16, 1986. On site at each CF base, our laboratory personnel will carry out the test procedures which are outlined below. One morning or one afternoon (i.e., a three hour period) will be allotted for completion of each test, with 10 to 15 CF personnel being tested at each station.

Low-High Crawl Station

Each person will crawl over grassy 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 1 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.

Truck Loading Station

Personnel will load first-aid boxes onto a military truck bed, simulated by a platform 1.33 m high. Beginning at a starting weight of 10 kg, the load will be increased by 5 kg for men and 2.5 kg for women with each successive lift until the individual's maximum is reached. Two versions of this procedure will be used in which the participants starting position is varied from within one step to 5 m from the platform. The maximum weight lifted will be recorded.

Additional Tests

In addition to assessing the physiological and biomechanical demands of the above tasks, CF personnel will 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 (Ottawa) or immediately after (Borden) the Ergonomics Research Laboratory testing.

Queen's Station

Queen's University tests which include Grip Strength Endurance, Flexed Arm Hang, 30-second arm and leg ergometer tests, and lifting tests using the Forces' own testing device, the Incremental Lifitng Machine (ILM) will be conducted during the testing week.

Perceived Exertion Questionnaire

The Low-High Crawl and Land Evacuation subjects will be asked to complete three short questionnaires. These are designed to assess initial attitude toward performing the task and the perceived importance of the testing prior to task performance. Post testing, subjects will be asked to rate the level of exertion required by the task. As with all other testing procedures, subject anonymity will be guaranteed. In all the above tests, participants are free to withdraw from testing at any time and for any reason.

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., ≥ 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 addressed. For example, kits containing necessary first-aid items (i.e., bactin ointment, band-aids and bandages, sun-screen ointment) and drinking water will be readily available.

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.

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

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 $\geq$ 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.

PARTICIPANT SCHEDULE

CFB Borden June 9-12, 1986

All Personnel

Briefing:	Monday June 9	8:00 to 9:00	Buell Building Theatre
Alternate:	Monday June 9	9:30 to 10:30	Buell Building Theatre
Lunch Break:		12:00 to 1:00	(Box Lunches)

Group A

Monday June 9	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2:	Low-High Crawl
Tuesday June 10	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Wednesday June 11	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 6:	Truck Loading
Thursday June 12	9:00 to 12:00	Station 7:	Incremental Stretcher
	1:00 to 4:00	Station 8:	Sand Bag Carry

Group B

Monday June 9	9:00 to 12:00	Station 2:	Low-High Crawl
	1:00 to 4:00	Station 3:	Entrenchment Dig
Tuesday June 10	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Wednesday June 11	9:00 to 12:00	Station 6:	Truck Loading
	1:00 to 4:00	Station 7:	Incremental Stretcher
Thursday June 12	9:00 to 12:00	Station 8:	Sand Bag Carry
	1:00 to 4:00	Station 1:	Queen's

Group C

Monday June 9	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Tuesday June 10	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 6:	Truck Loading
Wednesday June 11	9:00 to 12:00	Station 7:	Incremental Stretcher
	1:00 to 4:00	Station 8:	Sand Bag Carry
Thursday June 12	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2:	Low-High Crawl

Group D

Monday June 9	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Tuesday June 10	9:00 to 12:00	Station 6:	Truck Loading
	1:00 to 4:00	Station 7:	Incremental Stretcher
Wednesday June 11	9:00 to 12:00	Station 8:	Sand Bag Carry
	1:00 to 4:00	Station 1:	Queen's
Thursday June 12	9:00 to 12:00	Station 2:	Low-High Crawl
	1:00 to 4:00	Station 3:	Entrenchment Dig

Group E

Monday June 9	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 6:	Truck Loading
Tuesday June 10	9:00 to 12:00	Station 7:	Incremental Stretcher
	1:00 to 4:00	Station 8:	Sand Bag Carry
Wednesday June 11	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2:	Low-High Crawl
Thursday June 12	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation

Group F

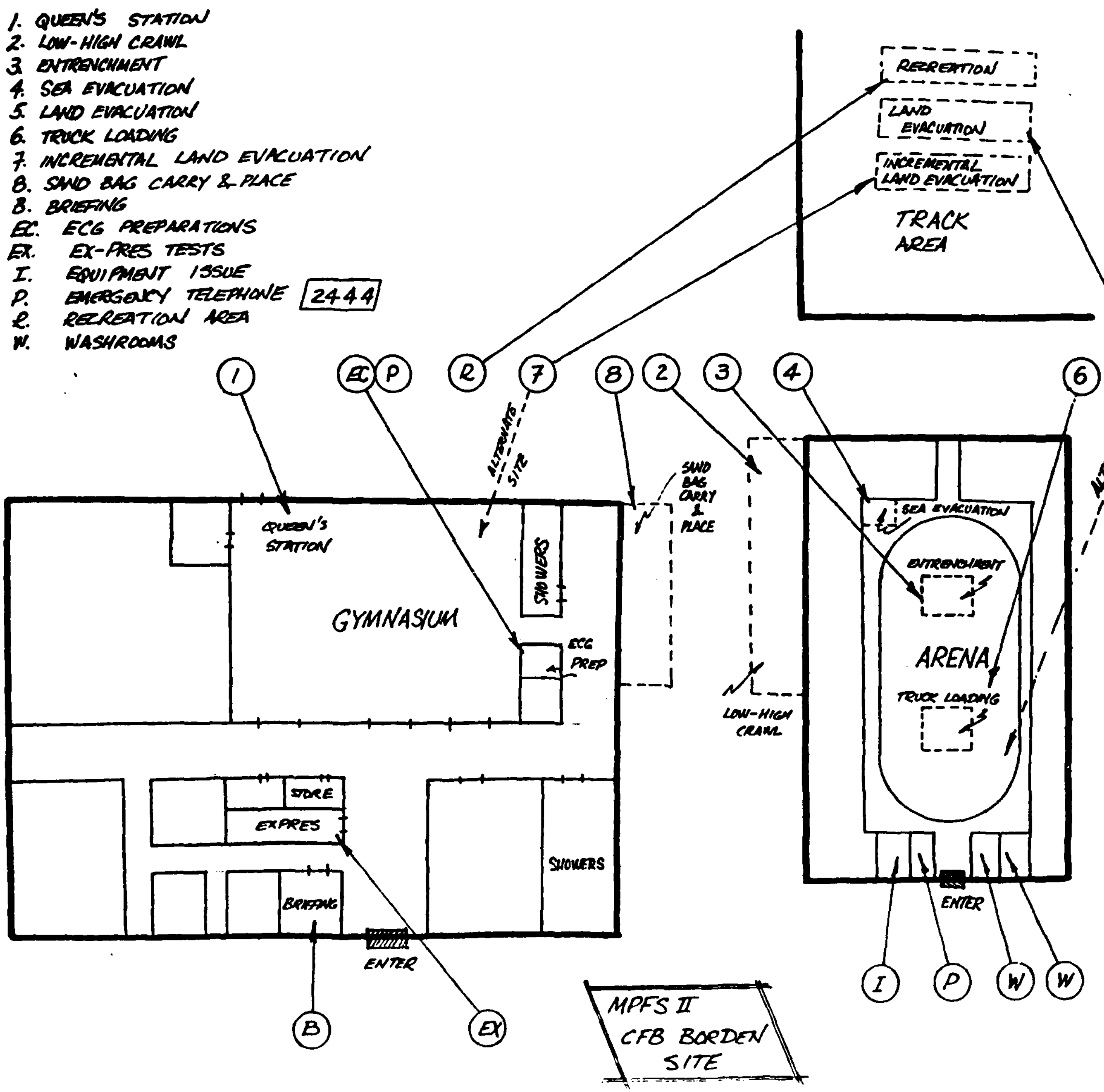
Monday June 9	9:00 to 12:00	Station 6:	Truck Loading
	1:00 to 4:00	Station 7:	Incremental Stretcher
Tuesday June 10	9:00 to 12:00	Station 8:	Sand Bag Carry
	1:00 to 4:00	Station 1:	Queen's
Wednesday June 11	9:00 to 12:00	Station 2:	Low-High Crawl
	1:00 to 4:00	Station 3:	Entrenchment Dig
Thursday June 12	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation

Group G

Monday June 9	9:00 to 12:00	Station 7:	Incremental Stretcher
	1:00 to 4:00	Station 8:	Sand Bag Carry
Tuesday June 10	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2:	Low-High Crawl
Wednesday June 11	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Thursday June 12	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 6:	Truck Loading

Group H

Monday June 9	9:00 to 12:00	Station 8:	Sand Bag Carry
	1:00 to 4:00	Station 1:	Queen's
Tuesday June 10	9:00 to 12:00	Station 2:	Low-High Crawl
	1:00 to 4:00	Station 3:	Entrenchment Dig
Wednesday June 11	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Thursday June 12	9:00 to 12:00	Station 6:	Truck Loading
	1:00 to 4:00	Station 7:	Incremental Stretcher


1. QUEEN'S STATION
2. LOW-HIGH CRAWL
3. ENTRENCHMENT
4. SEA EVACUATION
5. LAND EVACUATION
6. TRUCK LOADING
7. INCREMENTAL LAND EVACUATION
8. SAND BAG CARRY & PLACE
B. BRIEFING
EC. ECG PREPARATIONS
EX. EX-PRES TESTS
I. EQUIPMENT ISSUE
P. EMERGENCY TELEPHONE 2444
R. RECREATION AREA
W. WASHROOMS
RECREATION
LAND EVACUATION
INCREMENTAL LAND EVACUATION
TRACK AREA
ALTERNATE SITE
SAND BAG CARRY & PLACE
QUEEN'S STATION
GYMNASIUM
SHOWERS
ECG PREP
STORE
EXPRES
BRIEFING
ENTER
SHOWERS
LOW-HIGH CRAWL
SEA EVACUATION
ENTRENCHMENT
ARENA
TRUCK LOADING
ENTER
ALTERNATE SITE
MPFS II
CFB BORDEN
SITE

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 feels 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

INJURY FREE FITNESS

SIX KEY POINTS

Nothing wrecks a fitness program like injuries.

You're exercising regularly, enjoying it a lot and making good progress when suddenly [illegible] a pulled calf, or an over-stretched shoulder [illegible]. Sure, you'll recover, but both 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 occur 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 signs up for a fitness class and on the very first day walks in and struggles to stay with the leader [illegible] – 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. In a 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 in sports medicine clinics. Typically, these people have forgotten about progressive overload. Gung-ho hockey players are good examples. They may have spent a sedentary summer in a [illegible], their fitness slowly deteriorating. But come their first game in the fall and they go full tilt. Their chances of injury are high. Preseason 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 dancercise 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 strain on the lower legs. It's good, common sense prevention to alternate dancercise 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 [illegible] 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 shearing 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 side steps 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 strenuous activity your muscles 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 the first part of a work out we[illegible] when people are on a tight schedule. How many times have you seen someone come out of the locker room at a [illegible] and jump straight into a fitness class or basketball game without even a token warm up. That's 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. That isn't a good idea. A cold muscle is relatively [illegible], and trying to stretch it not only doesn't warm it, but can actually cause injury. The rule is warm up first, then stretch.

ERGONOMICS RESEARCH LABORATORY

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

Personal Data Summary Sheet

Name: ______________________ Group: ______________________

QUEEN'S FITNESS TESTING STATION			
Incremental Lifting Machine	6 ft.	________	kg
	5 ft.	________	kg
	other	________	kg
	other	________	kg
Anaerobic Leg Ergometer		________	kg.m/min
Anaerobic Arm Ergometer		________	kg.m/min
Flexed Arm Hang		________	s
Endurance Grip	R	________	s
	L	________	s
Maximum Grip	R	________	kg
	L	________	kg
LOW-HIGH CRAWL	total time	________	s
ENTRENCHMENT DIG	total time	________	s
LAND EVACUATION	total time	________	s
SHIPBOARD EVACUATION	total time	________	s
TRUCK LOADING			
Incremental Lift	Total Mass	________	kg
Incremental Lift-Carry-Lift	Total Mass	________	kg
SAND BAG CARRY	total bags	________	s
INCREMENTAL STRETCHER CARRY	total time	________	s

A125

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

Participant Information
CFB Ottawa June 16-20, 1986

Joan M. Stevenson, Ph.D.
George M. Andrew, Ph.D.
J. Timothy Bryant, Ph.D., P.Eng.
John M. Thomson, Ph.D.

Research Assistants

Sheryl French
Leslie Langley
Jennifer Williams
Marcia Thomson
Chris van den Berg

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

MINIMUM PHYSICAL FITNESS STANDARDS STUDY: PHASE II

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards for all military personnel. The underlying principle 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, 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 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. 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:

i) for male CF personnel to assess (and improve where necessary) minimum physical fitness requirements for 30-39 and 40-49 year old personnel; and
ii) with female CF personnel, to identify and quantify those components of physical fitness involved in performance of these tasks.

The Ergonomics Research Laboratory has been contracted to conduct this study at CFB Borden the week of June 9, 1986, and CFB Ottawa the week following, commencing June 16, 1986. On site at each CF base, our laboratory personnel will carry out the test procedures which are outlined below. One morning or one afternoon (i.e., a three hour period) will be allotted for completion of each test, with 10 to 15 CF personnel being tested at each station.

Low-High Crawl Station

Each person will crawl over grassy 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 1 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.

Truck Loading Station

Personnel will load first-aid boxes onto a military truck bed, simulated by a platform 1.33 m high. Beginning at a starting weight of 10 kg, the load will be increased by 5 kg for men and 2.5 kg for women with each successive lift until the individual's maximum is reached. Two versions of this procedure will be used in which the participants starting position is varied from within one step to 5 m from the platform. The maximum weight lifted will be recorded.

Additional Tests

In addition to assessing the physiological and biomechanical demands of the above tasks, CF personnel will 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 (Ottawa) or immediately after (Borden) the Ergonomics Research Laboratory testing.

Queen's Station

Queen's University tests which include Grip Strength Endurance, Flexed Arm Hang, 30-second arm and leg ergometer tests, and lifting tests using the Forces' own testing device, the Incremental Lifitng Machine (ILM) will be conducted during the testing week.

Perceived Exertion Questionnaire

The Low-High Crawl and Land Evacuation subjects will be asked to complete three short questionnaires. These are designed to assess initial attitude toward performing the task and the perceived importance of the testing prior to task performance. Post testing, subjects will be asked to rate the level of exertion required by the task. As with all other testing procedures, subject anonymity will be guaranteed. In all the above tests, participants are free to withdraw from testing at any time and for any reason.

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 addressed. For example, kits containing necessary first-aid items (i.e., bactin ointment, band-aids and bandages, sun-screen ointment) and drinking water will be readily available.

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.

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

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 $\geq$ 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.

PARTICIPANT SCHEDULE

CFB Ottawa June 16-20, 1986

"A" Group

Briefing: Monday June 16 8:00 to 9:00
Lunch Break 12:00 to 1:00 (Box Lunches)

Group A1

Monday June 16	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2: Station 6:	Low-High Crawl & Truck Loading*
Tuesday June 17	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Wednesday June 18	9:00 to 12:00	Station 5:	Land Evacuation

Group A2

Monday June 16	9:00 to 12:00	Station 2: Station 6:	Low-High Crawl & Truck Loading*
	1:00 to 4:00	Station 3:	Entrenchment Dig
Tuesday June 17	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Wednesday June 18	9:00 to 12:00	Station 1:	Queen's

Group A3

Monday June 16	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Tuesday June 17	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 1:	Queen's
Wednesday June 18	9:00 to 12:00	Station 2: Station 6:	Low-High Crawl & Truck Loading*

Group A4

Monday June 16	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Tuesday June 17	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2: Station 6:	Low-High Crawl & Truck Loading*
Wednesday June 18	9:00 to 12:00	Station 3:	Entrenchment Dig

Group A5

Monday June 16	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 1:	Queen's
Tuesday June 17	9:00 to 12:00	Station 2: Station 6:	Low-High Crawl & Truck Loading*
	1:00 to 4:00	Station 3:	Entrenchment Dig
Wednesday June 18	9:00 to 12:00	Station 4:	Shipboard Evacuation

"B" Group

Briefing:	Wednesday June 18	1:00 to 2:00	
Lunch Break:		12:00 to 1:00	(Box Lunches)

Group B1

Wednesday June 18	2:00 to 5:00	Station 1:	Queen's
Thursday June 19	9:00 to 12:00	Station 2:	Low-High Crawl &
		Station 6:	Truck Loading*
	1:00 to 4:00	Station 3:	Entrenchment Dig
Friday June 20	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation

Group B2

Wednesday June 18	2:00 to 5:00	Station 2:	Low-High Crawl &
		Station 6:	Truck Loading*
Thursday June 19	9:00 to 12:00	Station 3:	Entrenchment Dig
	1:00 to 4:00	Station 4:	Shipboard Evacuation
Friday June 20	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 1:	Queen's

Group B3

Wednesday June 18	2:00 to 5:00	Station 3:	Entrenchment Dig
Thursday June 19	9:00 to 12:00	Station 4:	Shipboard Evacuation
	1:00 to 4:00	Station 5:	Land Evacuation
Friday June 20	9:00 to 12:00	Station 1:	Queen's
	1:00 to 4:00	Station 2:	Low-High Crawl &
		Station 6:	Truck Loading*

Group B4

Wednesday June 18	2:00 to 5:00	Station 4:	Shipboard Evacuation
Thursday June 19	9:00 to 12:00	Station 5:	Land Evacuation
	1:00 to 4:00	Station 1:	Queen's
Friday June 20	9:00 to 12:00	Station 2:	Low-High Crawl &
		Station 6:	Truck Loading*
	1:00 to 4:00	Station 3:	Entrenchment Dig

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* Each group will perform Station 6 in the same time slot as Station 2. Half of the participants will begin at Station 2, proceding to Station 6 and the remainder will complete the two tasks in the reverse order.

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

Exercise , amstring 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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INJURY FREE FITNESS

SIX KEY POINTS

Nothing upsets a fitness program like injuries.

You're exercising regularly, enjoying it a lot and making good progress when suddenly a achilles strain, a pulled calf, or an over-stretched shoulder sends you to a doctor or put you on the sidelines. Sure, you'll recover, but both physically and emotionally, it can be hard to get going again.

We used to think that the occasional exercise injury was inevitable. Remember the old saying "No pain, no gain"? But now fitness experts feel that most aches, pains, sprains, and bruises occur 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 Coe, 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 shows up for a fitness class and on the very first day walks in 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. In a class participants should certainly follow the leader and work for improvement, but at their own pace and within their own limits."

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. Gung-ho hockey players are good examples. They may have spent a sedentary summer in a deck chair, 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 dancercise 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 kilometres 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 strain on the lower legs. It's good, common sense prevention to alternate dancersize 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 steering 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 [illegible] 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."

ERGONOMICS RESEARCH LABORATORY

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

Personal Data Summary Sheet

Name: ____________________ Group: ____________________

QUEEN'S FITNESS TESTING STATION

Incremental Lifting Machine	6 ft.	________	kg
	5 ft.	________	kg
	other	________	kg
	other	________	kg
Anaerobic Leg Ergometer		________	kg.m/min
Anaerobic Arm Ergometer		________	kg.m/min
Flexed Arm Hang		________	s
Endurance Grip	R	________	s
	L	________	s
Maximum Grip	R	________	kg
	L	________	kg
LOW-HIGH CRAWL	total time	________	s
ENTRENCHMENT DIG	total time	________	s
LAND EVACUATION	total time	________	s
SHIPBOARD EVACUATION	total time	________	s
TRUCK LOADING			
Incremental Lift	Total Mass	________	kg
Incremental Lift-Carry-Lift	Total Mass	________	kg