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Canada

# EVALUATION OF THE PHYSIOLOGICAL BASIS OF THE INDOOR STANDARDIZED OBSTACLE COURSE (ISOC), A TEST OF OCCUPATIONAL FITNESS FOR INFANTRY PERSONNEL


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# DEDICATION

To my friend, Bill Keener,
and my father, John Kimick.

**ABSTRACT**

A recent study had suggested that while a global, occupational performance test would be of great value for the land element of the Canadian Forces (that is, the army), it was unlikely that the results would correlate with specific physiological components. With this in mind, 43 volunteer, male subjects were evaluated in the laboratory for aerobic power ($VO_2max$), anaerobic lactic power (ALP), anaerobic alactic power (AAP), muscular strength, muscular endurance, and a series of 14 anthropometric measures. The results were analyzed to determine the correlation with performance on the Indoor Standardized Obstacle Course (ISOC), a proposed global performance test for infantry personnel.

The following variables were found to be significantly correlated at $p < 0.01$, with the best of three performances on the ISOC (coefficients are in parentheses): $VO_2max$ (-0.73), ALP (-0.70), grip strength (-0.62), chest-waist girth difference (-0.56), sum of four skinfolds (0.55), sum of three strength tests (that is, a strength index) (-0.51), bench press repeats (-0.49), and shoulder press strength (1-RM) (-0.40). Leg press strength (1-RM) (-0.31) and AAP (-0.31) were significant at $p < 0.05$. Through step-wise, multiple regression analysis, it was determined that 54% of the variance the ISOC performance could be accounted for by $VO_2max$, 76% by including the strength index, 79% by adding ALP, and 81% by considering the sum of skinfolds along with the previous three items. The ISOC performance significantly ($p < 0.01$) differentiated the top ten (23%) and bottom ten subjects on the basis of 24 physiological and performance variables.

The correlations of this study were higher than those found in recent United States Army research which compared laboratory measures with simulated combat tasks. It was concluded that the ISOC does reflect various important physiological variables and as such, would be of value in the physical fitness assessment of infantry personnel.

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Special thanks must be directed to the subjects and assistants who participated in this particular project. Their co-operation was outstanding.

Lastly and firstly, I am indebted to my wife, Adelle, and my son, Jordan, my family and friends for providing the inspiration to keep pushing to this finish line, so that life's race may begin fresh and anew.

"Mens sana in corpore sano"

# CHAPTER I

# THE PROBLEM

## Introduction and Rationale

The importance of physical fitness, and the measurement of it, is well recognized by the military (1-9) and is the subject of much applied research (10-15). In the past, the main concerns of the various studies seem to have been either: a. to determine fitness levels of various types of subjects such as infantrymen and sailors (16-18), military college cadets (19,20), and specific age groups (21-26); or, b. to develop physical fitness tests (27-30).

Traditionally, the standards and training requirements have been based upon "experience and subjective judgement rather than objectively determined requirements for successful performances" (31:piii). While serving the purposes at the time, the approach has resulted in a paucity of information on actual requirements for physical fitness to do specific jobs under specific conditions. A United States (US) Army physical training study group recommended in 1982, that the number one priority in applied fitness research must be to identify the fitness requirements of continuous combat operations (31). This was in keeping with a 1976 recommendation to the US military services that physical and operational fitness standards for job specialities be developed which "reflect the operational performance requirements in strength and stamina" (32:p1) needed for effective performance in specific jobs. Similar conclusions were made in the Canadian Forces (CF) following detailed task analyses of its approximately one hundred trades, a process which had been initiated in 1978 as a first step in the development of meaningful selection criteria and appropriate tests (33-35).

The CF have had fitness tests as a regular part of the annual assessment for many years and they are a common element in many other countries as well (8,32,36-38). Presently, in the CF, there are two levels of fitness assessment. The first level is common to all personnel. The EXPRES Plan battery (anthropometric measures, Canadian Aerobic Fitness Test (CAFT), push-ups, sit-ups, and grip dynamometer) is administered annually to ensure that each person has achieved a minimum level of physical fitness (39). It also features an exercise prescription which assists the individual to maintain or improve his/her fitness status. The second level is the trade or environmentally specific, operational performance test. To date, the Battle Efficiency Test (BET) is the only tool available to objectively assess the combat fitness of CF field unit personnel (40).

The BET consists of two, ten-mile (16 km) route marches, conducted on consecutive days. It must be completed in less than two hours and 45 min on each day. After the first march, a six foot (1.83 m) wall is climbed, an eight foot (2.44 m) ditch is jumped, and each person transports a soldier for 200 m using the fireman carry. The test is performed in groups of ten or more personnel and is physically and militarily challenging. While the BET is useful, and should be retained for assessing physical and mental stamina (41), it has a number of limitations. Myles et al. (42) have determined that it does not measure the physiological variables of $VO_2$max or endurance capacity. Furthermore, it cannot be conducted year round because of the weather, and therefore its application is restricted. When an outdoor test like the BET is conducted, differences in road surfaces and terrain impede test condition standardization (14). Lastly, while personnel are being tested, they may be far from medical facilities should a life-threatening accident occur.

One of the conclusions of the Myles group was that a need exists "for a more global index of the soldier's ability to meet the physical demands of his job" (42:p6). It should be a safe, simple, standardized test which is militarily challenging. A recently proposed indoor, standardized obstacle course (ISOC) appears to meet these conditions (43). In light of the recent trend to not rely exclusively upon experience and subjective judgment, it was thought of value to assess the physiological basis of the ISOC. This became the purpose of the study, bearing in mind the cautionary note of the Myles group that if a global test "was designed to place demands on several aspects of physical fitness, it is unlikely to correlate with specific components" (42:p7).

## Purpose of the Study

The purpose of the study was to evaluate the physiological basis of the ISOC. Specifically, the study compared performance on the ISOC with recognized laboratory measures of aerobic power, anaerobic lactic and alactic power, muscular strength, muscular endurance, and body morphology.

## Scope of the Study

Forty-three healthy, volunteer male subjects, aged 21 through 31 yr, participated in the study. They were first evaluated by a series of anthropometric, aerobic and anaerobic power, muscular strength, and muscular endurance tests on two separate days. They were then subjected to the ISOC in a military armoury on three different occasions. The subjects wore combat clothes with helmet liners, carried a rifle, and were asked to give their best effort each time. The best trial of the ISOC ($ISOC_B$) was used for statistical purposes.

## Limitations of the Study

The subjects' motivation could not be controlled during the testing although they were given standardized instructions. The subjects were young, fit volunteers but were relatively few in number. As such, they may not reflect the full range of personnel who would be found in an infantry battalion.

The five maximal tests were completed on different days for all subjects, except for three cases. Two subjects had to complete their first and second ISOC on the same day, separated by two hours rest. In both cases, the subjects were requested to do the first ISOC at an easy, controlled pace and, two hours later, their second at a maximal effort. The third subject, who was in excellent condition ($VO_2max$ of 65.3 $ml.kg^{-1}.min^{-1}$), completed his third ISOC six hours after the anaerobic bike test.

## Definitions

Maximum aerobic power (AP)($VO_2max$): the maximum amount of oxygen which can be consumed per unit of time by a person during a progressive exercise test to exhaustion (expressed in $l.min^{-1}$ (absolute AP) or $ml.kg^{-1}.min^{-1}$ (relative AP)) (44:p39). The maximum was taken to be when the subject could no longer continue due to fatigue.

Anaerobic lactic power (ALP): the maximum rate of energy output during a maximal effort highly saturated in glycolytic energy production, which lasts for 60 to 120 s (expressed in W (absolute ALP) or $W.kg^{-1}$ (relative ALP)) (45: p62). In the case of this study, 90 s was the criterion.

Anaerobic alactic power (AAP): the maximum rate of energy output during a maximal effort lasting for no more than 15 s (expressed in W (absolute AAP) or $W.kg^{-1}$ (relative AAP)) (45:pp62,67). In the case of this study, six s was the criterion.

Muscular strength: the tension or force that a muscle group can develop in a single, maximal contraction: against an immobile resistance (isometric or static); or through the full range of motion of the part(s) of the body being tested (isotonic or dynamic) (46:p79). The units used in this study were kg.

Muscular endurance: (or resistance to fatigue) the ability of a group of muscles to repeat a performance which requires a relatively high level of muscular force (dynamic endurance) or maintenance of a position (static endurance) against a counteracting force (47:p94). The units are usually the number of repetitions or the length of time. For absolute muscular endurance, the load is the same for all subjects and must be more than 15% of maximal strength. It should tend to be relatively heavy since this increases the correlation with maximum strength (48:p255).

# CHAPTER II

# REVIEW OF LITERATURE

## Introduction

The aim of this study was to evaluate the physiological basis of the ISOC (the indoor, standardized obstacle course). The ISOC is a global performance test which was designed to incorporate/simulate demanding infantry tasks (43). To date, there has been only limited research completed for the CF on job-related types of tests (42).

The chapter is divided into three sections. The first will briefly describe the infanteer's job along with the testing which is conducted in the armies of selected countries. This will provide an appreciation of the rationale for the types of physiological parameters which were considered for laboratory measurement. The second section reviews scientific work in the area of job-related fitness and the laboratory testing of it. The last section provides a brief overview of the physiological parameters which were examined in this study.

## An Infanteer's Job - The Requirement for Physical Fitness

There are a number of different sources of information which can be examined to fully appreciate the job of an infanteer. They include general military literature, technical and training manuals, infantry trade specifications, various occupational analyses, and, to provide an international perspective, fitness tests which are conducted in the armies of other countries. For the purposes of this study, the latter three sources were the most relevant.

The CF trade specifications state that by the end of an infantryman's first phase of training, he must be able to participate in offensive and defensive operations including advances, attacks, crossing of obstacles, rescuing casualties, constructing defences (trenches, obstacles, minefields, road blocks) and individual movements with a rifle (49). A more complete list of the over 500 tasks can be found elsewhere (50). No references are made in this source to rates of work, quantities, weights, or sizes. For this kind of information, one must examine the occupational analyses.

In 1978, the Directorate of Military Occupational Structures (DMOS) began to identify and quantify the most physically demanding tasks of the approximately 100 trades in the CF. Table 1 below presents fifteen such tasks for infantrymen as determined through a series of questionnaires given to the trades personnel, interviews with subject-matter experts and on-site evaluations (51). After examining these tasks, the general physiological requirements were deduced by the authors of the ISOC (43).

**TABLE 1**

**ANALYSIS OF PHYSICALLY DEMANDING INFANTRY TASKS (43)**

| Serial | Physically Demanding Tasks | Physiological Requirements |
|---|---|---|
| 1. | Parachuting | |
| | . pull risers & hold as required | upper body strength & muscular endurance |
| | . pull in & field pack chute | |
| | . carry chutes (30 kg) plus rucksack (40 kg) | total body strength & muscular endurance |
| | . walk/run/crawl off landing zone | aerobic & anaerobic power |

(Table 1 cont'd)

(Table 1 cont'd)

| Serial | Physically Demanding Tasks | Physiological Requirements |
|---|---|---|
| 2. | Pull toboggan | all of Serial 1 |
| 3. a. | Advance to contact & patrolling<br>. walk/run/crawl<br>. with weapon, web gear & ammunition | aerobic & anaerobic power<br>upper & total body strength & muscular endurance |
| b. | Forced march<br>. 25 mi in 8 hr<br>. combat clothing<br>. weapon<br>. rucksack (20 kg) | |
| c. | 10 mi BET<br>. on two consecutive days<br>. combat clothing<br>. weapon | |
| 4. | Physical training | all of Serial 3<br>flexibility and agility |
| 5. | Mountain climbing<br>. combat clothes<br>. 32 kg weight | total body strength & muscular endurance<br>agility |
| 6. | Rappelling | all of Serial 4 |
| 7. a. | Load/off load materiel<br>(2½ ton, 1¼ ton trucks)<br>. sand bags (29.5 kg)<br>. ammo boxes (30.8 kg)<br>. parachutes (30.0 kg)<br>. tentage (20.9 kg)<br>. rucksacks (40.0 kg)<br>. jerry cans (20.4 kg) | total body strength & muscular endurance (push, pull, lift, carry)<br>especially grip strength<br>back & abdominals (bending & lifting)<br>aerobic (depending on task)<br>anaerobic |
| b. | Load aircraft | |
| c. | Set up 81 mm mortar | |
| d. | Dig trenches 6 ft long x 5 ft deep | |
| e. | Lay minefields | |
| f. | Canoeing | |
| 8. | Military drill | aerobic |

The Defence and Civil Institute of Environmental Medicine (DCIEM) distilled the task selection further as shown in Table 2 (34). The concentration upon lifting and carrying items, that is tasks which involved strength, can be readily seen. This was as a result of the preliminary evaluation of their own findings (34) and the US military services reports (33) which suggested that the majority of the strenuous tasks involved the physical handling of materiel.

**TABLE 2**

**REPRESENTATIVE TASKS FOR INFANTRY WHICH REQUIRE A HIGH DEGREE OF MUSCULAR STRENGTH AND ENDURANCE, AS DETERMINED BY DCIEM (34)**

| Serial | Task | Weight (kg) |
|---|---|---|
| 1. | Lift modular tentage onto 2½ ton truck (133 cm) | 20.9 (46 lb) |
| 2. | Lift jerry can onto 2½ ton truck (133 cm plus 50 cm height of hands on handles) | 20.4 (45 lb) |
| 3. | Lift and carry sandbags 4.6 m (15 ft) | 29.5 (65 lb) |
| 4. | Lift 7.62 mm ammunition boxes (no handles - only ridges 17 cm from bottom) onto 2½ ton truck | 30.8 (68 lb) |

The physical fitness tests undertaken by an army should reflect the types of physiological characteristics which, on the basis of its experience, are deemed important. The synopsis which follows presents the tests in use in the armies of the United States, Great Britain, Sweden, and the Union of Soviet Socialist Republics. Table 3 provides a summary of the likely objectives of the fitness tests.

The United States Army evaluates its personnel using the Army Physical Readiness Tests (APRT) (36). A soldier can obtain up to 100 points for each of the three tests, namely push-ups in two minutes, sit-ups in two minutes, and a two-mile run. He must obtain at least 60 points in each event. The dress includes fatigues and combat boots.

There is a specialized test for groups like the ranger and special forces (37). The test involves six items: inverted crawl of 40 yd in 25 s; 37 bent leg sit-ups in one minute; 33 push-ups in one minute; run, dodge and jump a 26 yd course of four wooden obstacles and one shallow ditch in 24 s; two-mile run in 16.5 min or less; 15 m swim dressed in fatigue clothes, boots, rifle, and equipment for rangers or a 50 m swim with just fatigue shirt, pants, and combat boots for special forces. The dress for the first five items is fatigue pants, T-shirt, and combat boots.

The Regular Army of Great Britain has three types of physical fitness tests (38):

a. Army Personal Fitness Assessment (APFA);
b. Basic Fitness Test (BFT); and,
c. Combat Fitness Test (CFT).

The APFA is considered to be a diagnostic test which will provide the basis for a plan of fitness training. It is utilized primarily by selection and basic training units whose personnel are under 40 yr of age. The male version of the APFA consists of five test items: a step test using a 43 cm (17 in) bench on which a soldier makes 150 steps in five minutes; 4, 5, or 6 heaves (or pull-ups) depending upon one's age; 8, 10, or 12 trunk curls on an inclined balancing bench; 4, 5, or 6 dips on parallel bars; and a vertical jump test.

As with the APFA, the BFT is age and sex related. It is conducted twice a year. Men under 40 yr are required to walk and run in combat clothes (including boots) 2.4 km (1.5 mi) as a group in 15 min followed immediately by a best effort run of the same distance as individuals, in times of under 11.5 to 12.5 min. Men 40 yr and over have a choice of either doing the same tests as above (except that the standards for the second 2.4 km are under 14 or 15 min), or walking/running 4.8 km (3 mi) in under 29 or 30 min.

The third type of physical fitness test, the CFT, is an optional one which a branch of the Army can develop. This parallels the Canadian Army which administers the Battle Efficiency Test (BET) (a 16 km route march on two consecutive days) for its combat troops.

When a Swedish soldier enlists, he spends two days undergoing various screening tests (32). His physical fitness is assessed by a "Physical Working Capacity" test (a cycle ergometer performance) and a "Muscular Power" assessment. The latter is comprised of the weighted sum of three isometric strength tests, the hand grip, knee extensor, and elbow flexor.

The Soviet Union's system of assessment (32) is very comprehensive and is evidently integrated into a citizen's life. It was introduced in 1972 and is called the GTO program which translated means "Ready for Labour and Defence". At the age of ten, children perform seven events such as sprinting and swimming. Records are maintained throughout their youth and are available to the military at the time of their induction. From ages 19 to 28 yr, citizens are expected to perform ten events and achieve prescribed standards. A number of events have alternatives which are necessary due to climatic or geographic conditions. Some of the male events are: run 100 m and 1000 m; long jump; hurl a 700 gm grenade; ski 5 km; swim 100 m; pull-ups; shoot rifle; orienteer 25-30 km; obtain a level II sports ranking. In addition, the Soviet soldier reportedly undertakes a standard physical fitness test daily. He must complete a seven-event 100 m obstacle course in 80 s, regardless of his age (8).

TABLE 3

SUMMARY OF THE LIKELY OBJECTIVES OF ARMY FITNESS TESTS FROM SELECTED COUNTRIES

| Likely Objectives | Canada | United States Regular | United States Special | Great Britain APFA | Great Britain BFT | Sweden | Soviet Union |
|---|---|---|---|---|---|---|---|
| 1. Aerobic Power | Canadian Aerobic Fitness Test (CAFT) | 2 mi run* | 2 mi run*<br>50 m swim* with clothes | step test (5 min) | 2 x 2.4 km* run or 4.8 km walk* (40 yrs+) | Physical Work Capacity (cycle) | 1000 m run<br>X-country ski* (5 km)<br>orienteer* (25-30 km) |
| 2. Muscular Endurance | | | | | | | |
| a. Upper Body | push-ups | push-ups | push-ups<br>inverted crawl | pull-ups<br>dips on parallel bars | - | - | pull-ups |
| b. Abdominal | sit-ups | sit-ups | sit-ups | trunk curls | - | - | - |
| c. Lower Body | (CAFT) | (run) | (run) | (step test) | (run) | - | (runs)<br>(X-country ski) |
| 3. Muscular Strength | | | | | | | |
| a. Upper Body | hand grip | - | - | - | - | hand grip<br>elbow flexor | grenade throw* |

(Table 3 cont'd)

(Table 3 cont'd)

| Likely Objectives | Canada | United States Regular | United States Special | Great Britain APFA | Great Britain BFT | Sweden | Soviet Union |
|---|---|---|---|---|---|---|---|
| b. Abdominal | – | – | – | – | – | – | – |
| c. Lower Body | – | – | – | – | – | knee extensor | – |
| 4. Anaerobic Power | | | | | | | |
| a. Alactic | – | – | run, dodge, jump* (24 s) | vertical jump | – | – | long jump<br>100 m run<br>1000 m run<br>100 m swim<br>obstacle course*<br>(in 80 s) |
| b. Lactic | – | – | 15 m swim* with equipment<br>run, dodge, jump* (24 s) | – | – | – | |
| 5. Specific Skills | – | – | swim | – | – | – | swim<br>X-country ski<br>shoot rifle<br>sports ranking |
| 6. Anthropometry | | | | | | | |
| a. Height | yes | yes | yes | a medical concern | | unknown | unknown |
| b. Body Mass | yes | yes | yes | | | | |
| c. Other Measures | girth | triceps pinch | – | | | | |

* Simulates a possible military task

The above section illustrates the variety of tasks and tests and thus, the physiological characteristics which are thought to be important for infantrymen. This information highlighted the components which needed to be examined in the laboratory. Clearly, aerobic power, muscular endurance, and muscular strength are important. Anaerobic power and, because performance can be affected by one's shape or size, anthropometry, were the other two considerations.

## Determining Job-related Fitness

While the sports fields will continue to provide the major focus for applied research, the work place presents the exercise physiologist with an important research setting. Interest in non-athletic environments is, however, not new, particularly with respect to the military. During the World War II era, it challenged people like R.E. Johnson of the Harvard Fatigue Lab (52); Taylor, Buskirk, and Henshel (53); Behnke (54); and Fleishman (55). Even in the World War I period, Cathcart used British soldiers in some of his studies (52).

Recently, fitness testing related specifically to a job or class of jobs has come into prominence. This is probably due to the social/legislative pressures of modern society (32,33). Studies of firefighters (56-58), telephone employees (59) and steelworkers (60), in addition to those of Canadian and American military personnel (31,42,61) have been undertaken. The objective of this research has usually been to determine which fitness tests should be used to select potential employees for physically demanding jobs. Arnold et al. (60), outlined the following general approach used in determining such a fitness test:

a. examine the job in detail;
b. select either a representative sample of actual tasks which can be precisely replicated or simulated tasks which can be standardized;
c. measure a group of subjects with a battery of laboratory-type tests and the job tasks to identify which test correlates best with the performance of the task; then
d. use that fitness test for selection purposes.

R values (significant at $p < 0.01$) of 0.45 (59) to 0.89 (60) for three-variable models have been obtained. Usually, the representative tasks are rather involved or cumbersome so that simple tests which can be completed quickly in an office setting, are sought by businesses. The range of actual and potential savings by organizations from improved selection procedures have been reported to be from between $92,500 (57) to as high as nine million dollars annually (60).

The general approach of the above studies was similar to this thesis; however, the objectives were somewhat different as illustrated below.

<u>Objective of General Approach</u>

| | | | |
|---|---|---|---|
| A SIMPLE LABORATORY-TYPE TESTS | B Used to find correlation with | C TASK PERFORMANCE so that | D <u>Lab tests could be</u> used to confidently test personnel |

<u>Objective of Thesis Study</u>

| | | | |
|---|---|---|---|
| A LABORATORY TESTS | B Used to find correlation with | C TASK PERFORMANCE (ISOC) so that | D <u>ISOC</u> could be used to confidently test personnel |

The objective of investigating the physiological components of a global, operationally-oriented, performance test to determine if it should be considered as a test of physical fitness, is relatively new. It has only been attempted once in the CF. Myles et al. (42) compared the BET times with $VO_2max$ and endurance capacity. They found that neither $VO_2max$ (as measured by a protocol similar to that of Bruce) nor endurance capacity (as determined by blood lactate at the end of a six-minute treadmill run), correlated with the faster BET time. R values of 0.08 and 0.09 respectively were obtained. They recommended that a test which was a global index of a soldier's ability to do his job should be developed; however, based upon their experience, they were not optimistic about the possibility that significant correlations with specific fitness components could be obtained.

Daniels et al. (31), of the US Army, recently conducted a study which was primarily aimed at determining the correlations of aerobic power (measured by an interrupted, running treadmill protocol) and dynamic lift capacity (obtained through use of the incremental lift machine (ILM) (27)), with performance of five days of sustained, operational tasks as assessed by subject matter experts. As secondary objectives, they included the two-mile run and the APRT scores (36) in the analyses. The r values obtained when operational performance was compared with the fitness components were:

| | | |
|---|---|---|
| vs rankings of $VO_2max$ plus dynamic lift | -0.46** | ($p < 0.0005$) |
| vs dynamic lift capacity | 0.39* | ($p < 0.05$) |
| vs $VO_2max$ | 0.16 | |
| vs APRT scores | 0.04 | |
| vs two-mile run | 0.00 | |

With these results, they concluded that physical fitness components do correlate with operational performance. They felt that had their 33 subjects not been in such good aerobic condition (mean $VO_2max$ 53.6 $\pm$ 5.6 $ml.kg^{-1}.min^{-1}$), aerobic power might have been a more important factor. They saw non-significant trends which suggested that the better performers had better fitness scores. They did not comment on the lack of correlation of the APRT scores (sum of push-ups, sit-ups, and two-mile run scores) and two-mile time with performance.

Murphy et al. (61) reported the same relationship between performance on the same five-day operational scenario and anaerobic power as measured by upper and lower body Wingate tests (WT) and isokinetic endurance tests of elbow flexors and knee extensors using the Cybex dynamometer. They concluded that anaerobic power appeared to play an important role in the performance. There were two significant correlations (at $p < 0.01$). They were the upper body WT for peak power at 0.46 and mean power at 0.43. Peak power was defined as the mean power output in watts of the highest five second period - usually the first period. This reflects anaerobic alactic power. The second variable, mean power output, was determined over the 30 s period and is an indication of anaerobic lactic power.

This section illustrates that there has been limited study of the demonstrated relationship between job performance and physical fitness. It was found that the most common approach to determining job-related fitness requirements is through correlational analysis. A full range of correlational coefficients has been reported in the literature. Myles et al. (42) found correlations of 0.08 and 0.09 between what was thought to be a global performance test (BET) and the physiological measures of aerobic power and endurance capacity. They cautioned that an investigator should not be optimistic in using a correlational approach. Daniels et al. (31) found some low, significant correlations between a global measure of job performance (actual tasks performed over five days in a realistic setting) and the fitness measure of dynamic lift capacity (0.39) and the rankings of $VO_2max$ plus dynamic lift capacity (-0.46). The highest correlations (0.80+) were obtained by Arnold et al. (62) when they used various composite, steel workers' tasks and compared those performances with a variety of physiological measures, the most important being the arm dynamometer score.

It is clear from these studies that to be able to demonstrate reasonably high correlation coefficients, two basic components are needed. The first is to have a performance task or series of tasks, which are representative of the job and which, in fact, require specific physical fitness parameters. The second requirement is to determine the proper fitness components and select a reasonable battery of laboratory measures.

## The Measurement of the Various Physiological Parameters

An important aspect of the preparation for this study was the identification of the physiological components which would most likely be involved in the performance of the ISOC and secondly, the selection of a battery of laboratory tests and measures which would be reasonable indicators of these parameters. This section provides a review of research directly related to the measurement of various physiological parameters. Aerobic power, anaerobic power, muscular strength, muscular endurance, and body morphology will be discussed.

Energy production is one of the critical factors involved in human activity - be it sports or a job (62,63). It is a well-accepted principle that there are three interdependent sources of energy which may be used by the body concurrently and in different proportions, depending on the duration and intensity of the activity (44). The three sources - anaerobic alactic, anaerobic lactic and aerobic -

all contribute to regenerating the fuel, adenosine triphosphate (ATP), needed by the body (63).

Aerobic power tests are very often found in applied research due to:

a. the importance of aerobic (oxidative) metabolism in the performance of work/exercise which lasts more than two to four minutes (44,62-64). Even activities requiring repeated, short bursts of power, need the aerobic processes during the recovery phases (44). This source has a large capacity and therefore contributes the majority of the energy in longer duration activities noted above (45); and,

b. the relatively high state of standardization of the evaluation protocols (44, 53,65-67).

It is common to at least classify the subjects of a study on the basis of their relative aerobic power even when the purposes do not directly involve this parameter. The mean aerobic fitness levels of groups of military personnel of similar ages as the subjects for the present study has been reported by various researchers in different countries. Myles and Allen (22) found that a sample of 238 Canadian male soldiers, aged 17 through 24, had a mean $VO_2max$ of 53.2 $\pm$ 7.5 $ml.kg^{-1}.min^{-1}$ upon completion of their recruit training. Kowal et al. (13) reported very similar post-recruit training values for 85 American males, aged 17 through 22, of 53.3 $\pm$ 7.1 $ml.kg^{-1}.min^{-1}$ while Vogel et al. (68) found that 254 British males had a post-army recruit training mean $VO_2max$ of 45.3 $\pm$ 7.2 $ml.kg^{-1}.min^{-1}$. All studies determined $VO_2max$ on the basis of a submaximal bicycle ergometer test and used the Astrand - Ryhming Nomogram.

For trained infantrymen aged 18 through 24 yr, Myles et al. (16) reported a mean $VO_2max$ value of 49.2 $ml.kg^{-1}.min^{-1}$ as compared with 44.1 $ml.kg^{-1}.min^{-1}$ for a sample of 369 other CF personnel of the same age group, employed in different trades. The two means for the age group 18 through 29 years were 47.0 $ml.kg^{-1}.min^{-1}$ (n=227) for infantrymen and 41.6 $ml.kg^{-1}.min^{-1}$ (n=671) for other CF personnel. Thus, young infantrymen have greater aerobic power than males in other CF trades.

It is generally recognized that bicycle ergometer tests usually under predict $VO_2max$ as compared to direct measures on treadmills, by about 7 - 8% (65,67,69,70). In order to obtain the best possible values, it was decided to use the direct measure method and a treadmill. To meet the specificity criterion for tests as recommended by many exercise physiologists (44,65), the most representative activity of the infantry, walking, was identified and the Jetté multistage graded stress test (71), as outlined at Appendix A, was chosen. Using a direct measure, treadmill protocol for a group of 21 airborne infanteers, whose mean age was 19.2 yr, Myles et al. (42) obtained a mean $VO_2max$ of 57.3 $ml.kg^{-1}.min^{-1}$.

Anaerobic power tests. It has been suggested by Bouchard et al. (45:p61) that there is "little information available concerning the contribution of anaerobic metabolism to success in sports performances" and that routine anaerobic testing is not a common practice in many sport science laboratories. However, it is generally accepted that maximal efforts of short duration are highly dependent upon both the anaerobic alactic (ATP + CP) and lactic (anaerobic glycolysis) processes (62,63). Thus, tests indicative of these systems were reviewed.

There are two general types of tests. The researcher can either calculate the mechanical work done in a specified time or monitor the time involved in performing a specified amount of work. Bouchard et al. (45) suggested the latter approach was less preferable and less precise in their recent review of sixteen laboratory/field anaerobic power tests. In addition to the general types of tests, there are other specific items which must be considered. These include duration, mode of exercise, intensity (work load) and other minor factors.

Bouchard et al. (45) suggested that a general criterion of ten to fifteen seconds should be used for the alactic performance tests and 60 to 90 s for the lactic tests. Green's article on energy systems (63) states that the alactic system involves performances of less than 20 s and the lactic system of from 30 to 90 s. Guyton (72) and Astrand and Rodahl (64) suggest that the ATP + CP system's major energy contribution is only for a few seconds while the anaerobic glycolysis is for less than one to two minutes. Since the two anaerobic energy systems function on a type of continuum (62,63) and are very difficult to measure directly (45), it is not surprising that there are these time variations.

Further observations by other notable researchers are contained below. Margaria, Aghemo and Rovelli (73:p1662) stated that the first four to five seconds of work may be "indicative of the phosphagen-splitting mechanism". Simoneau et al. (74) quote observations made by Di Prampero (75,76) that the time for ATP + CP contribution in supra-maximal physical exercise was less than eight to ten seconds and in the ten second test of Ikuta and Ikai (77), power was maintained only until the seventh second. Simoneau's group decided upon ten seconds in the development of their alactic bike test, while Katch and Weltman (78) used six seconds. Five seconds was the time used in the Wingate test (79). For the purposes of this study, six seconds was used.

Newsholme (80) reported that the glycogen content for human muscle was enough for approximately 80 s of sprinting. Simoneau's group (74) observed that the lactic power output seemed to plateau after about 90 s in the two minute Katch test (78), and therefore used the 90 s criterion for their lactic power test.

The supporters of a shorter test for anaerobic lactic power tests - in the order of 30 to 40 s - point out that there is a high correlation between this time frame and a two-minute test (81) and that longer tests involve a higher aerobic component (82,83). The fact that there likely is an aerobic component even at ten seconds of work must be recognized along with the fact that there is as yet no universally accepted percentage of how much aerobic input is permissible. Gollnick and Hermansen (84) have stated that anaerobic processes contribute about 83% at ten seconds of maximum effort, 60% at 60 s and 40% at 120 s. Katch and Weltman (78) suggested that if a short performance test required the major percentage of it's energy from anaerobic means, then it would be considered anaerobic in nature. They then proposed a two-minute test. Considering Gollnick and Hermansen's calculations, it is likely that 90 s of all-out effort would tax at least 50% of the anaerobic processes. Thus, this criterion was used in the present study.

Seven of the 11 laboratory tests reviewed by Bouchard et al. (45), involved bicycle ergometers. Two used treadmills and two used stairs. Because of the bicycle's predominance, its safe nature, and its reliance on lower body power, a modified Katch bicycle ergometer procedure was chosen as the mode and basic protocol to measure both anaerobic alactic and lactic powers (78).

Load setting or intensity was another factor which had to be examined. Katch et al. (81) found that approximately a 5.5 kp setting was near the optimal load for normal subjects. Evans and Quinney (82) found that all of their subjects were able to perform a 30 s test at 5.0 kp, but some showed a decreased power output at 6.0 kp. Thus, for this study, an absolute resistance of 5.0 was used.

Katch and Weltman (78) reported that a limitation of their study might have been the inability of the subjects to maintain constant force on the pedals during the full pedal cycle. Lavoie et al. (85) found significantly (at $p < 0.05$) higher peak power outputs (anaerobic alactic power) and anaerobic capacity using toe stirrups for the 30 s, Wingate protocol. The Katch procedure was therefore modified to include toe stirrups.

Lavoie et al. (85) mentioned that in retrospect, they would have liked to have included blood lactate measures. Notwithstanding the observation by Simoneau's group (74) that blood lactate concentration does not appear to be a valid measure of anaerobic lactic capacity since the values obtained are often lower than maximal values reported in the literature (25 $mmol.L^{-1}$,(45)), blood lactate measurement was examined. It has been reported that lactate concentrations can be obtained by a reasonably simple and accurate method using automated lactate analyzers (86). The Kontron Medical (Roche) model 640 was available for the present study. The time to obtain peak blood lactate values is usually taken to be from four to five minutes (64,86). However, the time for peak values can vary according to the subject's state of fitness. Thomson and Garvie (83) found, for example, that sprinters and marathoners had approximately the same peak time of 4.2 min $\pm$ 0.5 after a 60 s maximal run while active but untrained subjects peaked at 5.9 min $\pm$ 0.6. For the purposes of this study, it was decided that a pre-test sample and a five minute post-test sample would be taken and analyzed immediately.

<u>Muscular strength and muscular endurance</u> are important for performance of activities which involve heavy physical work (31-34,46,87,88). The measurements of strength and endurance have been studied and discussed by many people over the years but because it is such a complex area, there

has been a certain amount of difficulty in achieving consensus due to such things as lack of standardized terminology, procedures, and instructions as well as a variety of physiological aspects of the subjects. Terminology has been a long standing problem. In the strength area, the terms explosive strength, power, velocity, energy mobilization, dynamic strength, speed, static strength and endurance have all been used (55). Others have discussed isometric, isotonic, and isokinetic forms of strength (46). For the purpose of this study, the simple terms and procedures involved in static and dynamic muscular strength and muscular endurance, as defined in Chapter I, will be used.

Caldwell et al. (89) tried to address the question of standardized procedures. Due to the difficulty of types of strength, they chose to begin with and standardize the most simple form - static strength. Others (90,91) have supported their approach. They recognized that verbal instructions given to a subject will have an influence on the result(s). Therefore, the instructions must be as uniform as possible. For example, in applying a force, a subject can jerk maximally, apply a gradual increase to maximum or quickly apply a force to maximum and hold. Kroemer and Howard (92), demonstrated significantly higher scores on grip strength for the first two methods over the third one. Caldwell's group recommended an increase to maximum during the first second followed by a three second hold.

The start position with defined angles and levers should be standardized for better repeatability (46,87,89) as well as the rate of performing an endurance task so as to either evoke a stretch rebound effect or not (46).

External factors can have a variety of influences. Kroemer and Marras (90) summarized the expected qualitative changes. Feedback of results, ego arousal, drugs, startling noise and hypnosis usually have positive effects. Goals, incentives, competition, and verbal encouragement may be positive or negative. Spectators and punishment have uncertain effects. Ikai and Steinhaus (93) gave quantitative changes which ranged from a 26.5% increase due to positive hypnosis to 12.2% for subject shouting to 7.4% for a pistol shot two to ten seconds before the effort to a 31.7% decrease due to negative hypnosis. Individuals react differently to external stimuli which are difficult to control and quantify. Therefore, as recommended by Caldwell et al. (89), this study did not offer external stimuli.

In examining the effect of repeated tests, Tornvall (87) found that two untrained and non-training individuals who were tested three times per week for 10 weeks, improved their scores in certain muscle groups after six or seven tests (for example, forward and backward trunk flexion) or had decreased scores (for example, knee, leg and elbow extension, elbow and finger flexion). If time permitted, it would be best to have everyone become very familiar with the testing apparatus. However, according to Tornvall, for the four muscular tests finally chosen, it is likely that there would have been no "training effect".

Comparisons of muscle groups and relationships have been examined. Assmussen et al. (94) reported correlations between symmetric muscle groups of 0.80. Also, correlations between flexors and extensors of the same extremity were moderately high. However, the correlations between muscles of different parts of the body were low (0.40 and less). Astrand and Rodahl (64) and others (95) suggest that general muscle strength should not be obtained by testing one muscle group but by a battery of, perhaps, three or four representative tests.

Tornvall (87) on the other hand, found that certain muscle groups were quite representative of general strength. The correlations were 0.89 for leg extensors, 0.72 for hip flexors, 0.70 for knee extensors, 0.69 for hand grip and 0.64 for elbow flexors. He also compared different regions of the body. He found that trunk and leg regions and that upper and lower body groups were closely related but that trunk and upper extremities were not.

Historically, strength indicies have been used for almost a century. Sargent's Intercollegiate Strength Test was devised in 1897 and was used for about 50 years. The ten measures included the strength of expiratory muscles, grip, back, legs, and arms (96).

Rogers developed his Strength Index (SI) in 1926 using seven measures. It was comprised of the sum of the right and left grip, back, leg and arm strengths and lung capacity. The arm strength was calculated by multiplying the sum of pull-ups and push-ups by (body weight/10 + height - 60). The achieved SI was then divided by the sex-, age-, weight-based norm and multiplied by 100 to give the Physical Fitness Index (PFI). The process of summing a number of gross scores, dividing it by "Normal" scores and multiplying by 100 became the pattern for stating many strength indices. However, because the norms were too high, the equipment expensive, the test too time-consuming and the high level of training required by the testers, others made simplifications. The regression equation correlations with the SI were at least 0.977. Equations were in the form of: factor a (leg lift) + factor b (arm strength) + constant (97).

Clarke developed cable tension strength test batteries in World War II and had correlations of 0.90+ (49). However, while the 38 tests and combinations are reliable and useful for research purposes, they were thought to be "not feasible as practical tests of isometric strength" (98:p225).

It appears that there are presently no strength indices which have universal acceptance and the early ones have fallen out of use due to use of test items which had "dubious validity" such as lung capacity in the Rogers SI and the use of maximum repetitions which leads to confusion and misinterpretation since they have an endurance component (99:p.114). Nevertheless, for the purposes of this study, a simple strength index was determined by summing three measures, from different sections of the body, to give an indication of muscular strength.

Finally, the question of relative versus absolute endurance was examined. There are benefits by using a fixed or absolute load (that is, everyone lifts 80 lb or 36.3 kg). This parallels most military tasks in that bags of cement for example, come in fixed masses. Also, strength and absolute endurance have a high correlation (from 0.75 to 0.97 (100:p412,46)). On the other hand, use of relative loads will assist in standardizing performance for comparison purposes (that is, lifting a mass which is a percentage of one's body mass). For jobs or activities where handling one's own body mass is important, for example in gymnastics, firefighting (pulling oneself up and onto a ledge) or mountain climbing, tests like pull-ups are sensible (46). Since the relationship between an individual's physiological measures and his performance was of prime importance, this study incorporated an absolute endurance test.

Body morphology data are usually included in studies of physical performance, particularly in the athletic area (62,101,102). Malina's review (103) of the anthropometric correlates of strength and motor performance focused on studies of "normal" subjects, rather than athletes. Whether it be in sports or not, people have perceived that there is a link between performance and body shape and size dating from as long ago as Biblical times, when 9.4 foot tall Goliath (104) was the champion of the Philistines. The literature was reviewed to identify which classification method or methods could reasonably be used for this study.

Height and body mass are among the most common and basic anthropometric measures used to help classify subjects. The CF uses height/body mass standards for its recruiting and ongoing assessment (105). Studies using CF personnel have reported the subjects' height and body mass as well (16,42). In addition to classification purposes, researchers have found some relationships with performance measures. Berger (48) states that there is a positive correlation between body size or mass and absolute strength, and a negative one between body mass and strength/mass ratio or relative strength. These relationships have been illustrated by considering the sport of weight lifting (46,99). The competitors who are the heaviest can lift more total mass (as could Goliath), but the mass they lift compared to their own body mass, is a lower ratio than the lifters whose body mass is less. Depending upon the performance task, height could have a positive effect as in basketball (106).

The relationship of body mass/height$^2$, originally called Quetelet's index and now referred to as the body mass index (BMI), is sometimes used in the clasification of subjects. The nomograph of Thomas et al. (107) or normative data such as that obtained in the Canada Fitness Survey (CFS) (108), can be used for interpretation. The Medical Branch of the CF recently introduced BMI into its patient evaluation (109).

Another anthropometric method which is currently being used by the CF (39), is the girth measure procedures of Jetté et al. (110), namely chest-waist differences for men.

Katch and Katch (111) observed that at least 100 prediction methods have been proposed since 1950, in an attempt to evaluate body fat. Obviously, there is little unanimity in this area. Some of the criticisms of the skinfold methods centre around the assumptions which are made in computing percentage of body fat, namely:

a. that the body's fat and non-fat masses have constant densities (0.900 and 1.100 mg/ml respectively); and,
b. that bone and muscle are present in the same proportion in different individuals (112).

Nevertheless, the Canadian Standardized Test of Fitness (CSTF) procedures (108), which have a well-respected advisory board, included skinfold measurement. However, rather than calculating percentage body fat and entering the controversy as to which equation to use, the recommendation was adopted to simply produce norms using sums of skinfolds. DCIEM has been using the sum of three skinfolds (triceps, subscapular, suprailiac) for many years (25). For males, DCIEM uses the standards of less than 35 mm as lean, 35 to 50 mm as acceptable, and greater than 50 mm as having "too much fat".

The last morphological procedure to be considered in this review of literature was that of somatotyping. With the modifications by Heath-Carter to the basic, three component concept of Sheldon (113), determinations are more objective. This may account for the continued interest in somatotyping in research. Athletes around the world, continue to receive the bulk of attention (114-116). For the purposes of comparisions of subjects in this study, the review by Carter (117) was used. In addition, Bailey et al. (118) have produced Canadian norms based upon participants in the YMCA Life Program. They reported that the average somatotype of a Canadian male,aged 20-29 yr, is 3.7-5.0-2.1. The only other comparable, Canadian somototype data was obtained by Ross (118). His mean for 153 male university students was 2.8-4.9-2.8 which suggests that they were less endomorphic and more ectomorphic than the Bailey group's sample. There are no published somatoplots of CF personnel for comparison purposes.

Because there is no single, universally accepted way to measure body morphology, a variety of methods were chosen for this study, namely height, body mass, BMI, chest-waist girth differences, sums of skinfolds, and somatotyping using the Heath-Carter method.

## Summary

This review of literature examined the infanteer's work, the research which has been conducted on job-related fitness and various physiological parameters.

An infantryman has a very physically demanding job which taxes the four major areas of aerobic and anaerobic power, muscular strength and muscular endurance. This was demonstrated subjectively through the analysis of fitness testing of armies in selected countries (8,32,36-38) and, to an extent, objectively in the work of task analysis (33-35,51). Studies into actual job-related fitness testing are few (31,42,56-61) and are a relatively recent phenomenon. The format for this type of research usually involves correlational comparisons for which there is a full range of coefficients - from -0.08 to 0.80+. The Canadian military research which has been conducted (42) has not been able to demonstrate any significant correlations whereas the US Army has obtained some low significant r values (31,61).

The literature on the measurement of various physiological parameters suggested that while standardization of tests is desired (89,119), there are still very few universally accepted protocols.. Some parameters like aerobic power have many well established principles of measurement and familiar protocols (44,53,65-67), while others, such as anaerobic power are less well developed (45). In the area of body morphology, familiar measures like height and body mass are still deemed of value in themselves and in the calculation of the BMI. Some of the basic principles upon which the many body fat prediction equations are founded are being questioned

(112). This has resulted in a movement away from the familiar calculation of percent body fat to the adoption of sums of skinfolds (25,108). Somatotyping of athletes has been carried out since the 1940's by advocates like Sheldon. The Heath-Carter procedures (113) popularized the concept even further and somatotyping now includes "normal" populations, with the work of Bailey et al. (118) being the most notable in Canada. Muscular strength and muscular endurance have a multitude of tests, procedures and principles. Some tests such as the grip strength and lifting 1-RM masses, are very common; however, many facets must be considered in standardizing these basic procedures (89-92).

# CHAPTER III

# METHODOLOGY

## Introduction

The main objective of the experiment was to evaluate the relationship between performance on the ISOC and recognized laboratory tests and measures. In addition, determining the best predictor of ISOC performance was a secondary objective. This information would indicate the kind of test that the ISOC is - namely aerobic, anaerobic lactic, anaerobic alactic, muscular strength, muscular endurance or some combination of the above. It would also suggest if body morphology had any noticeable effect on ISOC performance.

## Subjects

Forty-three healthy, male volunteers participated in the study. Of these forty were military personnel, two were Physical Education/Kinanthropology students and one was a commercial pilot. They were 21 through 31 yr of age. A physical description of their heights, body masses, skinfolds, aerobic and anaerobic powers is found at Tables 4 and 5.

## Testing Procedure

The following tests and measurements were administered as per the protocols found at Appendix A, between 0800 and 1230 hr. Figure 1 outlines the testing flow chart. Due to subject availability, some individuals had to do one or two of their ISOC tests in the afternoon.

| | |
|---|---|
| Day 1 | Laboratory procedures at University of Ottawa |
| (AM) | . consent forms, screening/lifestyle questionnaires |
| | . pre-exercise blood pressure/heart rate |
| | . anthropometric measures - height, body mass, five girths, five skinfolds, two bone breadths |
| | . grip dynamometer |
| | . aerobic power (treadmill) (71) |
| | .. 24 hours rest (minimum) |
| Day 2 (AM) | . anaerobic power (bicycle ergometer) (78) |
| | . 1-RM shoulder press, maximum bench press repeats using 80 lb (36.3 kg) 1-RM leg press (Universal Weight Machine) |
| | . 24 hours rest (minimum) |
| Days 3, 4, 5 (AM) | . ISOC test at Cartier Drill Hall |
| | . course familiarization/warm-up |
| | . run ISOC for best time |
| | (24 to 48 hour rest between tests) |

**Figure 1**

**Flow Chart of Tests and Measurements**

## Laboratory Testing

Day 1 Upon arrival at the lab, the subjects completed consent forms, the PAR-Q, and an activity/lifestyle questionnaire. Pre-exercise blood pressures and heart rates were determined using an anaeroid cuff and stethoscope. Anthropometric measures were taken. They were height, body mass, five skinfolds (triceps, biceps, subscapular, suprailiac, calf), five girths (chest, waist, gluteal, biceps, calf) and two bone breadths (humerus, femur) (108,120). Grip strength measures were taken using the TKK dynamometer (108).

The subject finished the first day of testing by performing his aerobic power test. The Jetté multistage, graded stress test protocol (71) was utilized. It involved continuous walking in gym shorts and running shoes on a motor-driven treadmill (Quinton 24-72). After an explanation/demonstration, the subject warmed up with a three minute work bout, then rested for two minutes as described in Appendix A. For the actual test, the slope and/or the speed were increased every two minutes. The subject walked continuously until he had to stop due to fatigue. Expired $O_2$ and $CO_2$ were collected in a Tissot gasometer and analyzed by a Godart-Statham paramagnetic Rappox $O_2$ Analyzer and Godart-Statham $CO_2$ Capnograph. The $VO_2$ and $V_E$ were recorded on a Narco Four-B Physiograph. EKG readings were taken for the last 15 s of each minute using a Cambridge VS4 portable electrocardiograph. Heart rates were continuously monitored on the Hewlett-Packard 760 Monitor Scope. The subject warmed down by slowly walking for three minutes on the treadmill, grasping the guard rail, if necessary. Heart rate and blood pressure monitoring continued while he was seated. He was permitted to shower after his heart rate was 100 bpm or lower.

Day 2. The subject performed the anaerobic power test using a modified Katch (78) protocol with a Monark bicycle ergometer, fixed with toe clips and an electric revolution counter. Finger tip blood samples were taken to measure lactate, prior to the test and five minutes after the test. The blood was analyzed using the Roche model 640 lactate analyzer immediately after each sample was taken. For the test, the subject was given a very light, one minute warm up pedalling at a rate of 50 rpm and a load of 1 kp. After a one minute rest, the subject was instructed to pedal at a maximum rate for a very short, unspecified length of time from a rolling, zero load start. The load was quickly set at 5 kp and the subject pedalled for 90 s with verbal encouragement. Upon completion of the test, the load was reduced to 0.5 kp and the subject pedalled at a comfortable, relaxed rate for a minute before dismounting and slowly walking about.

During the next 30 min, the subject stretched, relaxed, had some water or juice and then proceeded to the Universal Weight Machine to complete three muscular tests. The first test was the seated shoulder press for which his 1-RM was determined by a sequential addition of weights beginning at 40 lb (18.1 kg). The subject then did a maximum number of repetitions for the bench press using 80 lb (36.3 kg) at a cadence of 20 presses per minute. The test was terminated when the subject could no longer maintain the proper cadence. The last test was the seated leg press for which the subject's 1-RM was determined a by sequential addition of weights, beginning at 150 lb (68 kg).

## ISOC Testing

The subject underwent the ISOC test on three different mornings, usually with a 48-hour rest between tests. (See Appendices A-3 to A-7 for a complete description of the ISOC procedures and equipment.) He attempted to complete the course as fast as he could dressed in combat clothes (pants and shirt weighed 1.2 kg; boots 1.7 kg), a properly fitted helmet liner (0.5 kg) and carrying a FNC-1 rifle with breech block (4.5 kg) - total weight 7.9 kg (17.4 lb). He received a familiarization briefing and demonstration, and performed a warm-up prior to the test. Verbal encouragement was given during the test and a ten second post-exercise heart rate using a stethoscope was obtained immediately upon completion of the course. Three trials for the ISOC were used because it was thought that learning/improvement would be involved in the performance. The $ISOC_B$ trial (best of three trials) was used for analytical purposes, since there is evidence that people learn at different rates (120a).

**Statistical Analyses**

The raw data were transferred to standard data sheets and then entered on the University of Ottawa Amdahl main frame computer using the Conversational Monitor System (CMS). The Statistical Analysis System (SAS) was used to compute frequency distributions and descriptive statistics to represent the subjects' performances and measures. Correlations and stepwise multiple regression analyses were carried out to determine the relationships among the different variables. The levels of significance chosen were $p < 0.01$ for correlations and 0.15 for the regression models.

# CHAPTER IV

# RESULTS

## Introduction

The chapter is divided into four sections:

1. age and physical characteristics of the subjects as determined by the laboratory tests and measures;
2. performance results on the ISOC;
3. a comparison of the bottom ten performers and the top ten based upon their $ISOC_B$ times; and,
4. correlation and regression analyses of the results.

## Laboratory Results

Tables 4, 5, and 6 present a summary of the laboratory results which were obtained from the 43 subjects. Their mean age was 25.6 yr ($\pm$3.0).

The means of the anthropometric measures (Table 4) suggest that the group was in the upper portion of the Canadian military's "desirable" body mass for height range (105). The measures which are indicative of body fatness, namely, the sum of skinfolds, body mass index (BMI), and chest-waist differences, imply that the group was in the satisfactory range (39,108,121). The mean somatotype of 3.2-5.4-2.3 suggests that the group was endo-mesomorphic.

TABLE 4

AGE AND ANTHROPOMETRIC CHARACTERISTICS OF THE SUBJECTS (n=43)

| Variable | x | SD | Minimum | Maximum |
|---|---|---|---|---|
| Age (yr) | 25.6 | 3.0 | 21 | 31 |
| Height (cm) | 176.2 | 6.5 | 163.3 | 193.6 |
| Body mass (kg) | 73.8 | 8.5 | 59.6 | 98.8 |
| Body Mass Index | 23.8 | 2.7 | 16.7 | 32.8 |
| Chest girth (cm) | 95.2 | 5.0 | 85.6 | 106.5 |
| Waist girth (cm) | 81.6 | 6.8 | 69.7 | 97.0 |
| Chest - waist difference (cm) | 13.6 | 4.2 | 3.3 | 21.9 |
| Sum of three* skinfolds (mm) | 33.9 | 15.5 | 13.3 | 84.2 |
| Sum of four** skinfolds (mm) | 38.0 | 17.0 | 15.6 | 93.7 |
| Endomorph | 3.2 | 1.5 | 1.0 | 7.3 |
| Mesomorph | 5.4 | 1.1 | 1.8 | 7.5 |
| Ectomorph | 2.3 | 1.3 | 0.1 | 6.9 |

* triceps, subscapular, suprailiac

** triceps, subscapular, suprailiac, biceps

The mean aerobic and anaerobic power characteristics of the group are found at Table 5. The mean $VO_2max$ of 50.5 $ml.kg^{-1}.min^{-1}$ ($\pm$6.7) indicates that the group had a cardio-respiratory fitness level which, according to Jetté's classification, places them in the above average category (122). There was only one Respiratory Exchange Ratio (RER) less than 1.05 and the lowest heart rate taken in the last 15 s of the final work bout was 180 bpm. Forty of the 43 subjects (93%) had a maximum heart rate reading of 187 bpm or higher. These data suggest that the volitional end points of the subjects were very close to, if not at, their maximum efforts.

TABLE 5

AEROBIC AND ANAEROBIC POWER RESULTS OF THE SUBJECTS (n=43)

| Variable | x | SD | Minimum | Maximum |
|---|---|---|---|---|
| $VO_2max(l.min^{-1})$ | 3.7 | 0.5 | 2.5 | 5.1 |
| $(ml.kg^{-1}.min^{-1})$ | 50.5 | 6.7 | 39.8 | 65.3 |
| RER | 1.16 | 0.08 | 0.99 | 1.39 |
| Heart Rate (bpm) | 195.9 | 8.1 | 180.0 | 214.0 |
| $V_E(l.min^{-1}$,BTPS) | 121.3 | 22.3 | 84.3 | 167.4 |
| ALP(W) | 355.8 | 44.5 | 246.7 | 443.3 |
| $(W.kg^{-1})$ | 4.9 | 0.7 | 3.4 | 6.0 |
| AAP(W) | 812.8 | 114.5 | 600.0 | 1200.0 |
| $(W.kg^{-1})$ | 11.1 | 1.8 | 8.1 | 14.8 |
| Lactate $(mmol.L^{-1})$ | | | | |
| Pre | 1.7 | 0.5 | 0.9 | 2.9 |
| Post | 14.8 | 2.5 | 9.9 | 21.5 |
| Difference | 13.1 | 2.4 | 8.2 | 19.7 |
| Revolutions (revs) per time segment | | | | |
| a. 0-6 s | 16.3 | 2.3 | 12 | 24 |
| b. 6-18 s | 23.1 | 2.8 | 17 | 29 |
| c. 18-30 s | 17.3 | 2.6 | 12 | 24 |
| d. 30-42 s | 13.0 | 2.3 | 8 | 17 |
| e. 42-54 s | 10.3 | 2.1 | 5 | 14 |
| f. 54-66 s | 9.0 | 2.0 | 5 | 13 |
| g. 66-78 s | 9.0 | 2.1 | 5 | 16 |
| h. 78-90 s | 9.0 | 2.2 | 5 | 16 |
| Dropoff (rev) (b-h) | 14.3 | 2.8 | 5 | 19 |

Table 6 provides the muscular strength and muscular endurance results. The mean total grip strength of 111.0 kg

($\pm$11.5) is at the upper end of the "average" category according to the 1981 CFS standards (108). Five of the 43 subjects (12%) were classified as being in the weak category, that is, 96 kg or less, while six (14%) were rated as being excellent, that is, 124 kg or more. This indicates that there was a reasonably balanced range of strength performances.

**TABLE 6**

**MUSCULAR STRENGTH AND MUSCULAR ENDURANCE RESULTS OF THE SUBJECTS (n=43)**

| Variable | $\bar{x}$ | SD | Minimum | Maximum |
|---|---|---|---|---|
| Total grip strength (kg) | 111.0 | 11.5 | 83 | 139 |
| Shoulder press (kg) | 51.7 | 7.8 | 36.3 | 72.6 |
| Leg press (kg) | 168.3 | 31.1 | 111.1 | 258.6 |
| Sum of three strength tests (kg) | 331.1 | 38.8 | 245.7 | 435.1 |
| Bench press (reps) | 28.0 | 15.7 | 6 | 100 |

## ISOC Results

The subjects were requested to give their best efforts on the ISOC. The extent to which this was done is reflected in their immediate, post-performance heart rates which averaged over 187 bpm on each of the three trials (Table 7). For the third ISOC trial, 39 of the 43 subjects (91%) had a final heart rate of 180 bpm or higher. The $ISOC_3$ and $ISOC_B$ results were identical for 38 of the 43 subjects. The five $ISOC_2$ times, which were taken as $ISOC_B$, were on average only 2.8 s faster than the individuals' $ISOC_3$ times. There was no significant difference ($p < 0.05$) between $ISOC_3$ and $ISOC_4$ in the seven subjects who were able to do a fourth trial.

**TABLE 7**

**OBSTACLE COURSE (ISOC) RESULTS (n=43)**

| Variable | $\bar{x}$ | SD | Minimum | Maximum |
|---|---|---|---|---|
| ISOC 1 | | | | |
| time (s) | 360.2 | 55.5 | 282 | 505 |
| heart rate (bpm) | 187.7 | 13.0 | 162 | 210 |
| ISOC 2 | | | | |
| time (s) | 333.4 | 60.2 | 244 | 521 |
| heart rate (bpm) | 189.0 | 10.7 | 156 | 210 |
| ISOC 3 | | | | |
| time (s) | 317.0 | 50.9 | 242 | 477 |
| heart rate (bpm) | 187.8 | 9.9 | 156 | 204 |

**<u>Bottom Ten (BP) Performers vs Top Ten (TP) Performers</u>**

The ten subjects (23%) who had the slowest $\overline{ISOC}_B$ times (BP) were compared with the ten who had the fastest $ISOC_B$ times (TP) first to determine if there were differences in body morphology and performance and second to determine if the ISOC would differentiate between the bottom and top performers. Independent t-tests were calculated to identify significant differences at the $p < 0.01$ level.

Upon examination of Table 8, it is apparent that there were many significant differences between the two groups. There was a 127.7 s difference (48%) in the mean $ISOC_B$ times (BPs were slower than TPs), but there was no difference in the post-performance heart rates (184.4 bpm $\pm$ 11.7 for BPs vs 186.6 $\pm$ 10.0 for TPs). The BPs sum of four skinfolds (53.3 mm $\pm$ 22.8) placed them at the $75^{th}$ percentile as compared to the TPs whose sum (26.0 mm $\pm$ 6.7) was at the $15^{th}$ percentile (121). The BP mean somatotype was 4.5-5.4-1.7 (endo-mesomorph) while the TP mean was 2.2-5.2-2.8 (ecto-mesomorph). The BMI mean for the BPs was significantly greater at the 0.05 level, 25.3 $kg.m^{-2}$ $\pm$ 3.4 versus 22.8 $\pm$ 1.7, reflecting the $35^{th}$ and $65^{th}$ percentiles respectively (108).

The BP values for aerobic and anaerobic lactic power were approximately a quarter to a third lower than the TP values. The lactate difference, though lower for the BP (12.4 $mmol.L^{-1}$ $\pm$ 1.5 vs 13.9 $\pm$ 3.1) was not significantly different. This was similar for the anaerobic alactic power scores - BPs 795 W $\pm$ 160.6 vs 830.0 $\pm$ 53.7 and BPs 10.4 $W.kg^{-1}$ $\pm$ 2.0 vs 11.5 $\pm$ 1.2. The BPs had significantly fewer revolutions in the middle four, 12 s time segments (that is, the section 18 to 66 s of the 90 s bike test) with the percentage difference consistently increasing with time. They also had significantly fewer total revolutions.

The BP strength results were approximately 20% less than the TPs. The greatest percentage difference between the two groups was in the muscular endurance test where the BP mean was 140.6% lower than the TP.

TABLE 8

PHYSIOLOGICAL AND PERFORMANCE VARIABLES WHICH WERE SIGNIFICANTLY DIFFERENT ($p < 0.01$; INDEPENDENT t-TESTS) FOR THE TEN BOTTOM (BP) AND TEN TOP (TP) $ISOC_B$ PERFORMERS

| Variable (units) | Group | x | SD | Range | % Diff* |
|---|---|---|---|---|---|
| $ISOC_B$ (s) | BP | 393.6 | 38.2 | 351-477 | 48 |
| | TP | 265.9 | 12.9 | 242-277 | |
| Skinfolds (mm)** | | | | | |
| Sum of 3 | BP | 47.5 | 20.6 | 18.2-84.2 | 107 |
| (tri,sub,supra) | TP | 23.0 | 6.5 | 13.3-33.5 | |
| Sum of 4 | BP | 53.3 | 22.8 | 21.0-93.7 | 105 |
| (tri,bi,sub,supra) | TP | 26.0 | 6.7 | 15.6-37.0 | |
| Girths (cm) | | | | | |
| Chest-waist | BP | 9.5 | 4.4 | 3.3-18.6 | 74 |
| difference | TP | 16.5 | 3.1 | 12.6-21.9 | |
| Endomorph | BP | 4.5 | 1.8 | 1.7-7.3 | 105 |
| | TP | 2.2 | 0.7 | 1.0-3.4 | |
| Pre-exercise HR | BP | 74.8 | 9.6 | 60-88 | 26 |
| (bpm) | TP | 59.6 | 8.0 | 49-72 | |
| $VO_2max$ | BP | 42.3 | 1.7 | 39.8-45.3 | 33 |
| (ml/kg/min) | TP | 56.3 | 7.2 | 47.0-65.3 | |
| (l/min) | BP | 3.24 | 0.46 | 2.52-3.81 | 26 |
| | TP | 4.08 | 0.58 | 3.38-5.06 | |
| $V_E$(l/min) | BP | 104.4 | 16.7 | 84.3-133.0 | 26 |
| | TP | 132.0 | 22.4 | 100.5-160.5 | |
| ALP(W) | BP | 313.0 | 41.9 | 246.7-366.7 | 23 |
| | TP | 385.3 | 30.2 | 333.3-426.7 | |
| ALP(W/kg) | BP | 4.1 | 0.5 | 3.4-4.9 | 29 |
| | TP | 5.3 | 0.6 | 4.4-6.0 | |
| Total revs | BP | 93.9 | 12.6 | 74-110 | 23 |
| | TP | 115.6 | 9.1 | 100-128 | |
| Grip strength | BP | 100.7 | 7.3 | 92.0-112 | 22 |
| (total) (kg) | TP | 122.6 | 11.0 | 106-139 | |
| Shoulder | BP | 47.4 | 6.7 | 38.6-61.2 | 20 |
| press (kg) | TP | 56.9 | 8.8 | 45.4-72.6 | |
| Sum of 3 | BP | 302.1 | 44.2 | 245.7-408.2 | 17 |
| (kg)*** | TP | 354.6 | 31.5 | 311.7-405.4 | |
| Bench press | BP | 16.5 | 4.8 | 6-25 | 141 |
| (reps) | TP | 39.7 | 21.9 | 21-100 | |

* Diff = Difference

** Triceps (tri), biceps (bi), subscapular (sub), supra-iliac (supra) and calf skinfolds were all significantly different with percentages ranging from 71 to 130.

*** grip strength + shoulder press + leg press

## Correlation and Regression Analyses

Table 9 provides the correlation coefficients for selected physiological and performance variables. Since determining their relationships to the $ISOC_B$ time was the main aim of the study, this information is highlighted below. The variables and their coefficients are shown in descending order.

1. Significant at 0.01:

| | | |
|---|---|---|
| a. | $VO_2$max in $ml.kg^{-1}.min^{-1}$ | -0.73* |
| b. | anaerobic lactic power (ALP) in $W.kg^{-1}$ | -0.70 |
| c. | ALP in W | -0.69* |
| d. | $VO_2$max in $l.min^{-1}$ | -0.62 |
| e. | total grip strength in kg | -0.62 |
| f. | chest-waist difference in cm | -0.56 |
| g. | sum of four skinfolds in mm | 0.55* |
| h. | sum of three strength tests in kg | -0.51* |
| i. | bench press in reps | -0.49* |
| j. | shoulder press in kg | -0.40 |

2. Significant at 0.05:

| | | |
|---|---|---|
| a. | leg press in kg | -0.31 |
| b. | anaerobic alactic power (AAP) in $W.kg^{-1}$ | -0.31 |

3. Not significant:

| | | |
|---|---|---|
| a. | AAP in W | -0.27* |
| b. | BMI | 0.27 |
| c. | height in cm | -0.24 |
| d. | lactate difference | -0.22 |
| e. | body mass in kg | 0.12 |
| f. | drop off in revs | -0.11 |

(* denotes variables used in regression analysis)

Due to the relatively small number of subjects, only six representative variables were selected for use in multiple regression analysis for the dependent variable, $ISOC_B$ time. The six were chosen primarily on the basis of the correlation

TABLE 9

CORRELATION MATRIX OF SELECTED PHYSIOLOGICAL AND PERFORMANCE VARIABLES (n=43)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Height | – | | | | | | | | | | | | | | | | | | |
| 2 Body Mass | .30+ | | | | | | | | | | | | | | | | | | |
| 3 BMI | –.31+ | .81* | | | | | | | | | | | | | | | | | |
| 4 Sum 4 Skinfold | –.07 | .55* | .60* | | | | | | | | | | | | | | | | |
| 5 Chest-Waist Diff | .14 | –.34+ | –.43* | –.67* | | | | | | | | | | | | | | | |
| 6 AP(absolute) | .31+ | .40* | .20 | –.07 | .31+ | | | | | | | | | | | | | | |
| 7 AP(relative) | .06 | –.37* | –.41* | –.55* | .57* | .68* | | | | | | | | | | | | | |
| 8 ALP(absolute) | .24 | .28 | .13 | –.11 | .18 | .68* | .47* | | | | | | | | | | | | |
| 9 ALP(relative) | –.02 | –.52* | –.51* | –.54* | .42* | .28 | .71* | .66* | | | | | | | | | | | |
| 10 AAP(absolute) | .18 | .14 | .02 | –.19 | .04 | .15 | .07 | .24 | .12 | | | | | | | | | | |
| 11 AAP(relative) | –.06 | –.56* | –.53* | –.54* | .25 | –.14 | .32+ | .01 | .46 | .74* | | | | | | | | | |
| 12 La Difference | –.13 | –.26 | –.19 | –.36+ | .20 | –.00 | .23 | .32+ | .50* | .23 | .36+ | | | | | | | | |
| 13 Drop Off | .07 | .24 | .17 | .24 | –.22 | .12 | –.05 | .22 | .03 | .27 | .08 | .15 | | | | | | | |
| 14 Grip | .37* | –.03 | –.26 | –.36+ | .43* | .35+ | .38* | .42* | .39* | .26 | .23 | .29 | .08 | | | | | | |
| 15 Shoulder Press | –.17 | .17 | .26 | –.18 | .15 | .19 | .07 | .20 | .04 | .01 | –.10 | .11 | .10 | .29 | | | | | |
| 16 Leg Press | –.15 | .34+ | .43* | –.10 | –.04 | .12 | –.08 | .39* | .09 | .22 | –.02 | .19 | .24 | .05 | .52* | | | | |
| 17 Sum 3 Strength | –.04 | .30+ | .32+ | –.22 | .13 | .24 | .06 | .47* | .20 | .26 | .03 | .26 | .23 | .40* | .70* | .92* | | | |
| 18 Bench Press | –.03 | .00 | .00 | –.23 | .36+ | .29 | .26 | .33+ | .28 | –.13 | –.12 | –.00 | –.12 | .13 | .55* | .36+ | .43* | | |
| 19 $ISOC_B$ | –.24 | .12 | .27 | .55* | –.56* | –.62* | –.73* | –.69* | –.70* | –.27 | –.31+ | –.22 | –.11 | –.62* | –.40* | –.31+ | –.51* | –.49* | |

* – significant at $p < 0.01$
\+ – significant at $p < 0.05$
No notation – not significant

analysis. The best one, two, three, four, five and six variable models are presented in Table 10, based upon the SAS procedures of stepwise regression analysis. The significance level for entry into the model was 0.15. A relatively high percentage (79%) of the variance in $ISOC_B$ time can be accounted for by $VO_2max$, the strength index, and the ALP measure. A fourth parameter, sum of four skinfolds, increased the figure to 81%.

**TABLE 10**

**SAS STEPWISE, MULTIPLE REGRESSION ANALYSIS FOR SELECTED, REPRESENTATIVE VARIABLES AND BEST ISOC PERFORMANCE TIME (n=43)**

| Model | Variable | B values | Intercept | Significance | $R^2$ |
|---|---|---|---|---|---|
| 1 | $VO_2max$ | -5.53 | 596.34 | 0.0001 | 0.54 |
| 2 | $VO_2max$ | -5.32 | 790.68 | 0.0001 | 0.76 |
| | Strength index | -0.62 | | 0.0001 | |
| 3 | $VO_2max$ | -4.57 | 799.99 | 0.0001 | 0.79 |
| | Strength index | -0.49 | | 0.0001 | |
| | ALP | -0.25 | | 0.03 | |
| 4 | $VO_2max$ | -3.51 | 725.82 | 0.0001 | 0.81 |
| | Strength index | -0.39 | | 0.002 | |
| | ALP | -0.35 | | 0.005 | |
| | Skinfolds | 0.58 | | 0.05 | |
| 5 | $VO_2max$ | -3.30 | 703.19 | 0.0002 | 0.82 |
| | Strength index | -0.33 | | 0.01 | |
| | ALP | -0.34 | | 0.005 | |
| | Skinfolds | 0.57 | | 0.05 | |
| | Bench press | -0.42 | | 0.1 | |
| 6 | $VO_2max$ | -3.41 | 732.36 | 0.0001 | 0.83 |
| | Strength index | -0.29 | | 0.02 | |
| | ALP | -0.31 | | 0.01 | |
| | Skinfolds | 0.48 | | 0.1 | |
| | Bench press | -0.54 | | 0.05 | |
| | AAP | -0.05 | | 0.2 | |

**Summary**

The 43 subjects in this study were all reasonably fit, and represented a wide range of healthy males aged 21 to 31 yr. They performed the maximal tests with vigour as indicated by their maximal or near maximal heart rates. The $ISOC_B$ performances significantly ($p < 0.01$) differentiated the top 23% of the subjects from the bottom 23%. Upon examination of other variables, the top performers had significantly less body fat, lower pre-exercise heart rates, greater aerobic and anaerobic lactic power and greater muscular strength and muscular endurance.

$ISOC_B$ performance was also significantly ($p < 0.01$) correlated with nine selected variables which represent aerobic power, anaerobic lactic power, muscular strength, muscular endurance, and body morphology of the total sample. Regression analysis of the dependent variable $ISOC_B$ time, demonstrated that aerobic power accounted for 54% of the variance; that 76% was accounted for by the addition of a second variable, the strength index (the sum of grip, 1-RM shoulder press and 1-RM leg press); that 79% was accounted for by the inclusion of anaerobic lactic power; and, that 81% was accounted for by adding a fourth variable, the sum of four skinfolds.

# CHAPTER V

# DISCUSSION

## Introduction

The study's aim was to evaluate the extent of the relationship between ISOC performance and various physiological measures. Comparisons to other research as well as discussion of the limitations and implications of the ISOC study's results are presented in four sections: ISOC; anthropometry; aerobic and anaerobic power; and, muscular strength and muscular endurance.

## ISOC

All subjects had significantly ($p < 0.01$) better times for their $ISOC_2$ trials than $ISOC_1$ (with the exception of three subjects, for whom there were logical explanations). Therefore, the first trial should never be used as a "scoring" value. Since the $ISOC_2$ amd $ISOC_3$ trials were significantly ($p < 0.01$) different, there still was some learning effect taking place in most individuals. Due to biological variability, there is merit in taking the better of the second or third trials. However, because there were so few subjects who had better $ISOC_2$ that $ISOC_3$ trials, there could be an administrative advantage when applying the ISOC in a field setting, to ensure that candidates have at least two previous, non-scoring trials, then evaluating everyone on the basis of the third trial. It could also be a policy that the ISOC be used as a training mode and that the personnel routinely negotiate the course throughout the year. This would be similar to what is reportedly done in the USSR (8).

**Anthropometry**

The significant ($p < 0.01$) correlation coefficients of 0.55 for the sum of skinfolds and -0.56 for chest-waist girth difference with respect to the $ISOC_B$ performance, suggest that the ISOC differentiates between participants on the basis of body fat. In essence, excess body fat will likely hinder performance since fat is an inert mass which the soldier must carry, lift, and pull throughout the course. Due to the high intensity of effort and the relatively short duration of four to eight minutes, the possible advantage that an overfat person has, through the utilization of his fat as a primary fuel source, can not play a major role (84). If the course design required the soldiers to go through the ISOC many times at a lower intensity, the overfat individuals may not be as disadvantaged as they are under the present protocol.

While the results of this study apply only to the subjects evaluated, some comparative data, extracted from military studies involving Canadian infantry soldiers (25) are presented at Table 11. Using the sum of three skinfolds criterion (triceps, subscapular, suprailiac), the under 25 yr old ISOC subjects had similar distributions as the infantry personnel (Table 11). There was, however, a marked difference for the age group 25 to 29 yr. No ISOC subject had a sum greater than 50 mm, the "too much fat" criterion used by DCIEM (25), while the infantry battalion had approximately 43% in this category. Further, by examining Table 8, the group of bottom performers (BPs) had a mean of 47.5 mm ($\pm$ 20.6) which is close to the 50 mm criterion for overfat. Thus, if the ISOC was applied to infantrymen under 30 yr of age, it is possible that there will be a large percentage of overfat infanteers, 25 to 29 yr of age, who will be slower on the ISOC than their lean counterparts.

TABLE 11

COMPARISONS OF SKINFOLD SUMS BETWEEN TWO AGE GROUPS OF CANADIAN INFANTRY (25) AND THE ISOC STUDY SUBJECTS

| Variable | Classification | Under 25 yr Infantry (n=162) | Under 25 yr ISOC (n=16) | 25 - 29 yr Infantry (n=65) | 25 - 29 yr ISOC (n=24) |
|---|---|---|---|---|---|
| Sum of three skinfolds* (mm) | lean (< 35) | 55% | 50% | 29% | 71% |
| | acceptable (35-50) | 28% | 25% | 28% | 29% |
| | too much fat (> 50) | 17% | 25% | 43% | 0% |

* Classification based upon that used by DCIEM (25)

There were no significant correlations at the 0.01 level between the $ISOC_B$ time and height, body mass, or BMI. The comparison of the ten bottom performers (BPs) and ten top performers (TPs) revealed no significant differences, although the trend was that the BPs were heavier and shorter. On the basis of this study's results, it is likely that very few infantrymen will be disadvantaged due to their height or body mass when performing the ISOC.

The military does not utilize somatotyping in its selection of personnel; however, it is interesting to note the difference in the mean body shape of the BPs - with shapes similar to those Carter reported for golfers - and the TPs who were shaped like rowers, track sprinters, and sprint cyclists

(102). Since the ISOC does seem to require high power outputs typical of sprinters and rowers, the test may differentiate performers on the basis of somatotypes. An examination of the correlation coefficients shows that only the endomorph component at 0.56, is significant ($p < 0.01$). Since a sum of three skinfolds is utilized in its determination, it is not surprising to see a coefficient which is of the same magnitude as those related to body fat. The mean BP is an endo-mesomorph (4.5-5.4-1.7) as is Bailey's (118) average 20-29 yr old Canadian (3.7-5.0-2.1). The mean TP, being an ecto-mesomorph (2.2-5.2-2.8) is different than the average Canadian whom the CF recruits. It may be of value for the CF to examine representative samples of personnel in the over 100 trades and classifications, to determine if there is a natural, self-selection of military applicants with respect to particular somatotypes. This may help recruiters to identify more accurately suitable candidates for the specialized trades where great amounts of resources are spent for training.

## Aerobic and Anaerobic Power

Table 12 presents data which compare infantry (25) and ISOC subjects based on $VO_2max$ classifications and means. The under 25 yr age groups were similar (infantry mean 49.2 $ml.kg^{-1}.min^{-1}$ vs 48.6) and the distribution between classifications was approximately the same. For example, 18% of infantry had poor to fair values versus 13% of the ISOC subjects. However, there were noticeable differences in the 25 - 29 yr age groups. Fully 52% of the infantry had poor to fair scores as compared with only 8% of the ISOC subjects, and their mean $VO_2max$ was 41.5 $ml.kg^{-1}.min^{-1}$ versus 52.7 for the ISOC participants. If the aerobic power values of the top and bottom performers presented at Table 8 are considered for comparisons, the TP value was similar to the elite infantry studied by Myles et al. (42) (56.3 $ml.kg^{-1}.min^{-1}$ for TPs vs 57.3), while the BP value was similar to the regular infantry group aged 25 to 29 yr (42.3 $ml.kg^{-1}.min^{-1}$ for BPs vs 41.5). This suggests that the ISOC study group had a variety of aerobic power scores which were similar to different infantry groups. It also suggests that the ISOC will be able to differentiate top aerobic performers from bottom performers.

**TABLE 12**

**COMPARISONS OF $VO_2MAX$ CLASSIFICATIONS BETWEEN TWO AGE GROUPS OF CANADIAN INFANTRY (25) AND THE ISOC STUDY SUBJECTS**

| Variable | Classification | Under 25 yr Infantry (n=162) | Under 25 yr ISOC (n=16) | 25 - 29 yr Infantry (n=65) | 25 - 29 yr ISOC (n=24) |
|---|---|---|---|---|---|
| $VO_2max$* ($ml.kg^{-1}.min^{-1}$) | poor (< 33.7) | 7% | 0% | 16% | 0% |
| | fair (33.8-42.5) | 11% | 13% | 36% | 8% |
| | good (42.6-51.5) | 43% | 69% | 30% | 42% |
| | excellent (> 51.6) | 39% | 19% | 19% | 50% |
| | x | 49.2 | 48.6 | 41.5 | 52.7 |

* Classification based upon that suggested by Cooper (30) and utilized by DCIEM (25)

The correlation between the $ISOC_B$ time and the relative $VO_2max$ value was the highest of any variable measured in this study (-0.73). This suggests that aerobic power is an important component of ISOC performance and that the ISOC is indicative, to a degree, of one's $VO_2max$. This is probably due to the fact that the test requires the use of large muscle groups at a high intensity (indicated by heart rates in the order of 180 bpm) for a time period (four to eight minutes) which necessitates the utilization of the aerobic system (44).

## TABLE 13

### CORRELATIONS OF VARIOUS FIELD TESTS AND $VO_2$MAX AS MEASURED DIRECTLY USING A TREADMILL PROCEDURE

| Researcher | | Field Test | Correlation |
|---|---|---|---|
| Burke | (123) | 12 min run | 0.90 |
| Cooper | ( 30) | 12 min run | 0.897 |
| Myles et al. | ( 28) | 2.4 km run | -0.88 |
| Ribisl & Kachadorian | (124) | 2 mi run | -0.85 |
| Myles et al. | ( 28) | 4.8 km run | -0.83 |
| Burke | (123) | 600 yd run | 0.78 |
| | | 1 mi run | -0.74 |
| Kimick | | ISOC | -0.73 |
| Ribisl & Kachadorian | (124) | 1 mi run | -0.67 |
| | | 880 yd run | -0.67 |
| Myles | (125) | British BFT | -0.67 |
| Myles et al. | ( 42) | Canadian BET | 0.08 |

Table 13 illustrates that the ISOC correlation with $VO_2$max is not of the magnitude of maximal 12 min, 2.4 km, or 4.8 km runs, but it is higher than some shorter maximal runs of up to one mile, the British Army's BFT - back to back 2.4 km runs in combat clothes, and the Canadian Army's BET - 16 km route marches in combat clothes.

Another valuable aspect of the ISOC to note is its high correlation with anaerobic lactic power (-0.70). For the four to eight minute performance, the body's reliance on the anaerobic energy system switches emphasis to the aerobic system after about two minutes at which time the approximate proportions are 4% anaerobic alactic, 46% anaerobic lactic and 50% aerobic (44). However, there are eight times during the ISOC when a physically demanding manoeuvre (other than running) of from 10 to 60 s is required such as an ammunition box carry, a tire pull, a sandbag carry, a crawl, or an overhead ladder traverse. This utilization of other muscle groups in an intermittent fashion, suggests a high requirement for the anaerobic lactic energy and may account for the relatively high r value. The ISOC may be a reasonable field test of anaerobic lactic power although it does not provide results in the units recommended for standardization of the general category of test (45) nor does its duration fit into the traditional time frame of 30 to 120 s. It is interesting that neither lactate difference nor drop-off in revolutions were significant since they would seem to be related to anaerobic lactic power. Lactate difference was significantly correlated with anaerobic lactic power (relative at 0.50, absolute at 0.32). However, the drop-off was not significantly correlated with any measure.

There was only one correlation coefficient (-0.31) which had significance ($p < 0.05$) between an anaerobic alactic power measure and the $ISOC_B$. It was the relative anaerobic alactic power measure expressed in $W.kg^{-1}$. This result was also reflected in the comparison of BPs and TPs as there were no significant differences between the two groups in these variables. It seems that the primary requirement on the ISOC is not for short, maximal power outputs, even though there are approximately 60 times that a short burst of power is required (for example, stop, start, jump, lift, push).

## Muscular Strength and Muscular Endurance

The correlations between $ISOC_B$ and two of the three strength measures, the strength index, and the muscular endurance measures were all significant at 0.01 and ranged from -0.62 to -0.40. This suggests that the activities on the ISOC were muscularly challenging. It is interesting that the one strength measure which was not significant at 0.01 (but was at 0.05) was leg strength. This would suggest that the strength and endurance of the upper body were critical to ISOC performance. Similarly, Murphy et al. (61) and Daniels et al. both concluded that upper body strength and endurance were important to performance of combat scenario tasks. The same information is displayed in the comparison of the BPs and TPs (Table 8) which includes the largest percentage difference of 140.6% in muscular endurance. This indicates that the ISOC may be a reasonable field test for muscular strength and muscular endurance.

## Summary

It was found that aerobic (-0.73) and anaerobic lactic (-0.70) power, upper body strength (-0.62), body fat (-0.56), and muscular endurance (-0.40) were all significantly correlated with $ISOC_B$ performance. This is in contrast to what Myles et al. (42) would have expected. While the simplest, quickest method of determining a person's ISOC time is for him to actually run through the course, the multiple regression analysis did give an indication of the amount of variance that could be accounted for by different combinations of variables. Aerobic power, strength, anaerobic lactic power and body fat together, contributed to this figure being over 80%. This suggests that the ISOC would be an excellent field test for the infantry, to the extent that the above four physiological factors are deemed important by military leaders.

It was also noted that while the scores on $VO_2max$ and sum of three skinfolds indicated a similar distribution of study subjects and infantry personnel evaluated by DCIEM (25) for the age group of under 25 yr, this study's subjects aged 25 to 29 yr were more fit than the infanteers of the same age group. Thus, care must be exercised when applying the results of this study to the infantry.

Finally, it was observed that the first ISOC trial should not be used for field evaluation purposes. The ideal application of the ISOC could be as a training medium. Thus, it would be used regularly, as is done in the USSR (8). The evaluation trial would take place long after all learning effects have been reduced to presumably an insignificant level.

# CHAPTER VI

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

### Summary

The CF is interested in a field test which is physically demanding, easy to administer, and which validly identifies individuals who are fit to perform their jobs (42). The recently designed ISOC test has many such desirable features. The aim of this study was to examine the relationship between performance on the ISOC and a wide range of laboratory fitness measures, to determine the physiological basis of the test.

A group of 43 healthy, reasonably fit males were evaluated. Forty of the subjects were military personnel serving in the Ottawa area. Their mean age was 25.6 yr ($\pm$ 3.0) and mean $VO_2max$ was 50.5 $ml.kg^{-1}.min^{-1}$ ($\pm$ 6.0) Twenty-six physiological tests and measures were carried out. Using correlation analysis of the results of all of the subjects and comparisons of the bottom and top ten performers on their best of three ISOC trials ($ISOC_B$), the following items were found to be significantly ($p < 0.01$) related to ISOC performance. (The r values are in parentheses.)

1. aerobic power as measured directly by a graded, maximal TM protocol (-0.73);
2. anaerobic lactic power as determined by a modified Katch, 90 s bicycle ergometer protocol (-0.70);
3. muscular strength as measured by the grip dynamometer (-0.62), 1-RM shoulder press (-0.40) on the Universal Weight Machine and a strength index (0.51) consisting

of the sum of the above two items plus the 1-RM leg press on the Universal;

4. body fatness as indicated by sum of four skinfolds (0.55) and chest-waist girth difference (-0.56);
5. muscular endurance as measured by the number of 80 lb bench presses (-0.49) completed at a rate of 20 reps per min using the Universal;
6. body shape as reflected by somatotypes (Heath-Carter method); a 4.5-5.4-1.7 endo-mesomorph (similar to a golfer) performed more poorly than a 2.2-5.2-2.8 ecto-mesomorph (similar to a rower, track sprinter or sprint cyclist);

These correlations are higher than those found in the US Army studies (31,61) and would be unexpected by Myles et al. (42). The significant physiological parameters of this research are the same as found in the sustained operations study (31,61). In addition, evidence that body morphology as reflected by body fat and somatoplots, may also be factors in the performance of the ISOC, is presented.

Performance on the ISOC was not significantly affected ($p < 0.01$) by:

1. the subject's height, body mass or BMI;
2. anaerobic alactic power as determined by the modified Katch, 90 s bicycle ergometer protocol (watts or watts.kg$^{-1}$ obtained in the first six s of the test); or
3. leg strength as measured by 1-RM leg presses on the Universal Weight Machine.

Stepwise, multiple regression analyses using six representative variables provided a model in which $VO_2$max, the strength index, anaerobic lactic power, and the sum of four skinfolds accounted for 81% of the variance for the $ISOC_B$ performance. A two variable model using $VO_2$max and the strength index had a $R^2$ value of 0.76.

## Conclusions

Within the limits of this study, the following conclusions have been made.

1. The best of three trials of the ISOC significantly ($p < 0.01$) reflects an individual's aerobic and anaerobic lactic power, muscular strength, body composition, and muscular endurance.
2. To the extent that the above five physiological characteristics collectively are deemed important by an infantry commander, the ISOC would be of value in the assessment of his troops.

## Recommendations

Further research is recommended as follows.

1. Determine the relationship between ISOC performance and combat effectiveness as assessed in field exercises. The similarity of this study's findings with those obtained by the US Army with respect to sustained combat scenarios, is encouraging.
2. It would be interesting to conduct the ISOC at the end of a 16 km route march to determine if subjects with higher amounts of body fat would perform as well as, or better than, leaner personnel. An alternative approach which addresses a similar hypothesis, would be to have the ISOC repeated continuously for a given number of times but at a lower intensity.
3. The effects of flexibility, coordination, and agility on ISOC performance were not addressed in this study. The influence of these factors could be examined.
4. The ISOC may be useful as a training modality and could be investigated and compared to other, more traditional, unit training programs.

## LIST OF ABBREVIATIONS

| | |
|---|---|
| AAP | Anaerobic alactic power |
| ALP | Anaerobic lactic power |
| AP | Aerobic power |
| APFA | Army Personal Fitness Assessment (Great Britain) |
| APRT | Army Physical Readiness Test (United States) |
| BET | Battle Efficiency Test (Canada) |
| BFT | Basic Fitness Test (Great Britain) |
| BMI | Body mass index |
| BP | Bottom performers (10) |
| CAFT | Canadian Aerobic Fitness Test |
| CF | Canadian Forces |
| CFS | Canada Fitness Survey |
| CFT | Combat Fitness Test (Great Britain) |
| CMS | Conversational Monitor System |
| CSTF | Canadian Standardized Test of Fitness |
| DCIEM | Defence and Civil Institute of Environmental Medicine |
| DMOS | Directorate of Military Occupational Structures |
| ISOC | Indoor Standardized Obstacle Course |
| $ISOC_B$ | Best of three trials on the ISOC |
| La | Lactate |
| MLVW | Medium logistics vehicle wheeled |
| RER | Respiratory Exchange Ratio |
| SAS | Statistical Analysis System |
| TP | Top performers (10) |

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# APPENDICES

# APPENDIX A

## PROTOCOLS

## GENERAL INSTRUCTIONS

To provide consistent, external motivation, subjects were not tested in view of other subjects for any muscular strength or muscular endurance tests, nor did the tester give verbal encouragement during the performance of these tests. Verbal encouragment was given during the anaerobic power, aerobic, and ISOC tests.

The time taken between the muscular tests on the Universal Weight Machine ranged from two to five minutes during which time each test was explained and demonstrated, and the subject performed his three warm-up lifts with light weights. The sequence for these tests was 1-RM shoulder press, maximum repetitions for the bench press using 36.3 kg (80 lb) and 1-RM leg press.

The handle gripping was standardized for the Universal Weight Machine tests by having the thumb and fingers form a "C" rather than an "O".

When the subject "stalled" during his 1-RM test, the load was reduced by 4.5 kg (10 lb) and a "piggy-back" of 2.3 kg (5 lb) was added for a final lift attempt.

# APPENDIX A-1

## Muscular Strength and Muscular Endurance

Grip strength (108)

Equipment: grip is adjusted for hand size of subject. Second joint of fingers should be snuggly under the grip with handle portion at base of thumb. Dynamometer is held in line with forearm at level of thigh and squeezed vigorously. Neither hand nor dynamometer should touch body or any other object. Two trials per hand, alternating hands.

Scoring: record score for each hand. Maximum of each are added together.

Additional notes for tester: ensure grip is slightly wider rather than narrower when adjusting. Record to the nearest kilogram.

Reliability: 0.90 (99:p113)

0.92 and 0.90 for right and left hand strength in boys 7-13 years (n=72) (126:p171)

0.91 (55:p59) based on male senior high school, university freshmen, unspecified n.

Validity: 0.72 (55:p65) correlation with a static strength factor (n=201 United States Navy recruits)

1-RM Shoulder press

Equipment: Universal Weight Machine, stool (69 cm high)

Description: sit on stool with feet flat on floor or stool cross bar. Handles are gripped so that the hands are slightly wider than shoulder width. There should be no hyperextension of the lower back. Using a smooth, controlled movement, fully extend arms.

Scoring: maximum weight lifted on one repetition.

Additional notes for tester: lightly place your hand on the back of subject to assist him in keeping his back straight. Begin at 18.1 kg (40 lb) and increase the weight by two plates at a time (9.1 kg) for the first three lifts, there after by one plate.

Reliability: 0.98 (99:p104) for a similar type of movement but using free weights and a standing position. Better of two trials was used.

Validity: face validity accepted for this test of arm extension strength in a vertical overhead press movement (99;p104).

0.87 (48:p38) correlation with total strength (sum of six isotonic, 1-RM strength tests using barbells, n=174 young adult males).

Objectivity: 0.99 (99:p104) was reported.

1-RM Leg press (127:p200)

Equipment: Universal Weight Machine

Description: sit in chair and place feet on upper foot rests so that quadriceps are approximately vertical to the floor. Ensure heels are closer together than balls of feet. This requires that the knees are spread wider than the feet. Grasp sides of chair for stability. Ensure that gluteals remain in contact with the seat at all times. Fully extend legs raising the weights and lowering the weights under control.

Scoring: maximum weight lifted in one repetition.

Additional notes for tester: begin at 68 kg (150 lb) and increase two plates at a time for the first three lifts, thereafter by one plate.

Reliability: none reported.

Validity: construct validity claimed (127:p200)

Maximum bench presses using 36.3 (80 lb)

Equipment: Universal Weight Machine, metronome, bench (65 cm long, 43 cm high)

Description: lie on a bench with feet positioned on end of bench. Using a practice weight of 22.7 (50 lb), grip bar so that all fingers wrap around bar in same direction, hands being slightly more than shoulder-width apart. Make three practice lifts using a three second rhythm for each repetition (metronome will be set at 40 beats per minute). Now using 36.3 kg, complete as many repetitions with full extension of your arms.

Scoring: number of properly completed repetitions.

Additional notes for tester: there is no time limit. Ensure the subject maintains the cadence. If he cannot maintain the cadence, stop the test.

Reliability: 0.93 (99:p101) for 1-RM.

Validity: none reported.

## APPENDIX A-2

### Jetté Multistage Graded Stress Test

| Stage* | Minutes | MPH | % Grade |
|---|---|---|---|
| Warm-up | 3 | 3.0 | 0 |
| Post warm-up | 2 | sitting | – |
| 1 | 2 | 3.0 | 2.5 |
| 2 | 2 | 3.0 | 5.0 |
| 3 | 2 | 3.0 | 7.5 |
| 4 | 2 | 3.5 | 7.5 |
| 5 | 2 | 3.5 | 10.0 |
| 6 | 2 | 3.5 | 12.0 |
| 7 | 2 | 3.5 | 14.0 |
| 8 | 2 | 3.5 | 16.0 |
| 9 | 2 | 3.75 | 16.0 |
| 10 | 2 | 3.75 | 18.0 |
| 11 | 2 | 3.75 | 20.0 |
| 12 | 2 | 3.75 | 22.0 |
| 13 | 2 | 3.75 | 24.0 |
| 14 | 2 | 3.75 | 26.0 |
| 15 | 2 | 4.0 | 26.0 |

* Because the fitness levels of the subjects were reasonably good, the odd numbered stages up to 11 were usually omitted.

# APPENDIX A-3

## INSTRUCTIONS TO SUBJECTS FOR ISOC

### Aim of Test

Go through the course in your best time, negotiating the obstacles in the prescribed manner.

### Dress and Personal Equipment

Ensure the following items fit properly:

a. combat boots, shirt, pants;
b. helmet liner;
c. FNC-1 rifle with breech block, magazine and sling, but with no ammunition. (NOTE, the sling is to be adjusted so that the rifle can be quickly slung across both shoulders. The ends of the sling are to then be taped.)

### General Concept of the Course

The course is approximately 430 m in length and is comprised of a series of 19 obstacles or tasks. They are arranged in five lanes on a drill hall floor. It will probably take from five to eight minutes to complete the course. Therefore, appropriate pacing is important. The course has been designed to tax your muscular strength and muscular endurance as well as your cardio-respiratory system (or aerobic power).

The general scenario or setting for the course is that you are in or near enemy territory. Unless specified otherwise, you will be required to carry your rifle at the low port position or, in the case of crawling, with hands on the forestock and the butt. For five obstacles, the weapon will be slung across both shoulders.

**Prior to Beginning the Course**

1. You will walk through the course with the instructor and rehearse the way in which you will perform each task/obstacle.
2. Warm-up by slowly jogging at least one lap of the drill hall and systematically stretching all parts of your body under supervision of the instructor.
3. Remember safety - of yourself and your equipment. In particular, when you lift or lower an object, keep your back straight and bend your knees. When you jump, absorb the shock by flexing your ankles and knees, and bending at your waist.

# APPENDIX A-4

## DIAGRAM OF ISOC LAYOUT

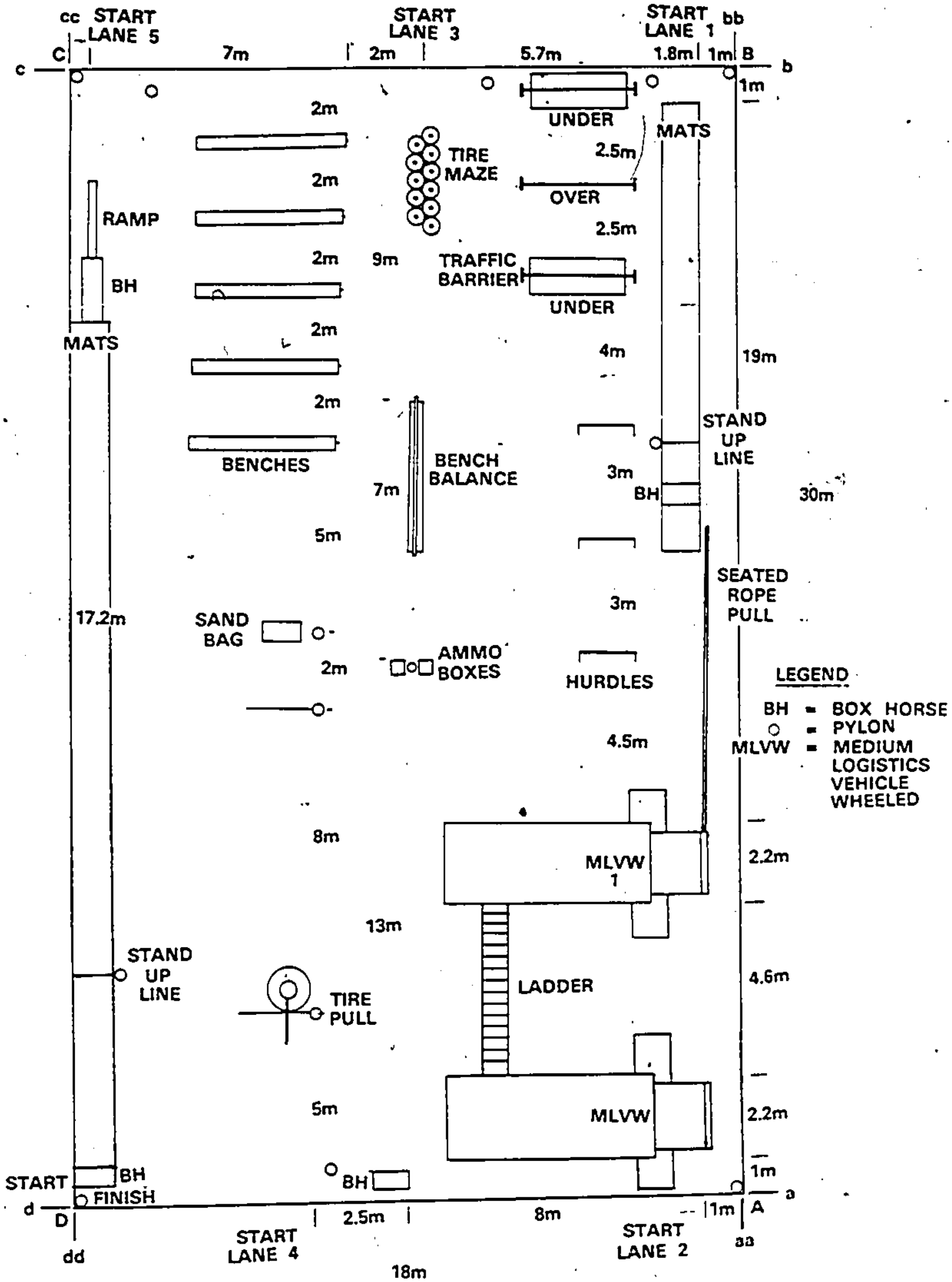



Figure 2 - Layout of Indoor Standardized Obstacle Course (ISOC)

# APPENDIX A-5

## DETAILED DESCRIPTION OF THE ISOC

## THE ISOC

| Obstacle/ Event Number | Name | Description |
|---|---|---|
| 1. | Run 1.5 laps (distance 135 m) | Rifle is to be at the low port position, approximately 45 degree angle, with elbows lightly at your sides and index finger outside of the trigger guard. |

**Lane One Obstacle**

| | | |
|---|---|---|
| 2. | Leopard crawl (distance 9 m) | Assume prone position while both feet are still on the cement floor (ie, body from your lower leg and above are on the mat). |
| | | With rifle in the ready position, hands on the forestock and handle or butt, move by alternately pivoting on your knees and elbows, keeping a low silhouette. The buttocks should be lower to the ground than the shoulders. |
| | | When your elbows touch the tape marker (which is 4 ft or half a mat (1.2 m) from the next obstacle), stand up and prepare for Barrier 1. |
| 3. | Barrier 1 (height 3.5 ft or 1.07 m) | Cross horizontally, with a low profile. |
| | | With both hands remaining on your rifle, place upper body on the box horse, but to one side of it, and swing your lower body on to the top of the box horse. |

| | | |
|---|---|---|
| | | Push off the top, land on your feet and step to your left, slinging your rifle over both shoulders, BARREL UP. |
| 4. | Seated pull | Sit down beside the marker on the floor, facing the truck, with your legs straight in front of you and the rope by your side.<br><br>Grasp rope at tape marker, take up the slack and pull yourself forward until your hand touches the second tape marker on the rope. (Pass the rope on your side as you pull yourself, ie., do not pile it on your lap).<br><br>Stand up, unsling rifle as you run to the next obstacle. |

**Lane Two Obstacle**

| | | |
|---|---|---|
| 5. | Low crawl 1 | Assume prone position on the mat as per obstacle 2 above.<br><br>Crawl under the vehicle, ensuring not to strike head on undercarriage of truck.<br><br>When elbows touch tape marker, stand up and move to the left and the next obstacle, slinging your rifle over both shoulders, BUTT UP. |
| 6. | Horizontal ladder (total distance, 24 ft or 7.3 m) | Jump up and using both hands, grasp rung marked with tape.<br><br>Traverse length of ladder, one rung at a time, alternating hands, to the second rung marked with tape.<br><br>While still hanging, turn 180 degrees and return to the first tape mark using same technique as at the beginning. |

| | | |
|---|---|---|
| | | Grasp the last rung with both hands and drop to the ground, absorbing the shock of landing with flexion of your ankles, knees and waist. Remember not to bend too far since your barrel is pointing down. |
| | | Start unslinging your rifle as you move to your left. |
| 7. | Low crawl 2 | As per obstacle 5 above. |
| | | Upon completion, assume low port position and begin running towards the hurdles. |
| 8. | Low hurdles (3) (2.5 ft or 0.76 m) | Jump each hurdle in any manner. |
| 9. | Under/over/under (height 2.5 ft or 0.76 m) | Assume prone position on the mat with body parallel to the first barrier. |
| | | Roll sideways and stand up. |
| | | Step or jump over next barrier. |
| | | Roll under last barrier. |
| | | Move to your left around the pylon. |

**Lane Three Obstacles**

| | | |
|---|---|---|
| 10. | Tire maze (11 tires) | Run through the maze ensuring to step into the centre of each tire. |
| | | Try not to touch any part of the tire. |
| 11. | Reversed bench balance (12 ft or 3.66 m) | Traverse it as quickly as possible. |
| | | If you fall off, return to the beginning of the bench and try again. |

| | | |
|---|---|---|
| | | As you proceed to the next obstacle, start slinging your rifle BARREL UP. |
| 12. | Ammo box lift, carry, and load (58 lb or 26.3 kg) (total distance 40 m) | Bend at knees, grasp edges of first box and with a straight back, lift to waist height. |
| | | Quickly carry the box to the back of the first MLVW, putting it on the flatbed and pushing it forward. |
| | | Unsling rifle and place it (do not drop it) on the left side of the flatbed. |
| | | Using the footstep, get onto the flatbed. |
| | | Push the ammo box to the front wall of the flatbed, touching it with the box, and push it back to the edge of the tailgate. Leaving the box on the edge of the flatbed, jump off the truck, absorbing the shock as per obstacle 6 above. |
| | | Sling weapon over both shoulders, BARREL UP. |
| | | Take ammo box and return it to the original spot. DO NOT DROP IT. Bend knees and with straight back, lower it on to mark. |
| | | Take second ammo box and repeat the process using the second MLVW. |
| | | Unsling your rifle as you proceed to the next obstacle. |
| 13. | Barrier 2 (height 4.5 ft or 1.38 m) | Cross as per obstacle 3. |

Upon landing, proceed to your right around the pylon, slinging your rifle across both shoulders, BUTT UP.

**Lane Four Obstacles**

| | | |
|---|---|---|
| 14. | Tire pull (weight 150 lb or 68 kg) (total distance 16 m) | Grasp the rope near the end and rotate the tire 180 degrees so that you are pulling it up the course, toward the benches.<br><br>You may face any direction as you pull.<br><br>When the leading edge of the tire touches the end line, rotate the tire 180 degrees and pull it back to the start line.<br><br>Try to pull it in a straight line so as to cover the shortest distance.<br><br>With the rifle remaining slung, proceed to the next obtacle. |
| 15. | Sandbag lift and carry (weight 65 lb or 29.5 kg) (total distance 60 m) | Bend your knees and with a straight back, lift sandbag up and onto one shoulder.<br><br>Carry it through the maze of five benches and return through the maze.<br><br>Bend knees and lower the sandbag to the original position. DO NOT DROP IT FROM STANDING POSITION.<br><br>Unsling your rifle as you proceed to next obstacle. |
| 16. | Low hurdles (5) (height 1 ft or 0.3 m) (2 m between each) | Jump over the five benches and move to the left around the pylon. |

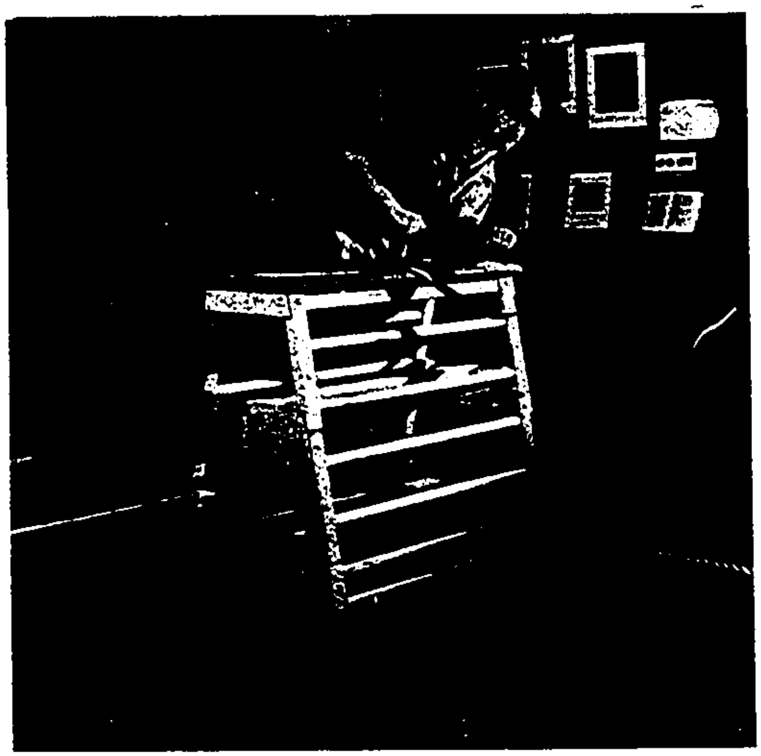
**Lane Five Obstacles**

| | | |
|---|---|---|
| 17. | Ramp, run, jump (height 3.7 ft or 1.1 m) | Run up the ramp and across the length of the box horse.<br><br>Jump and land, absorbing the shock by going into a forward roll. (Place rifle on ground in front of you and perpendicular to your line of advance and roll over the top of it.) |
| 18. | Leopard crawl (distance 17 m or 55 ft) | Proceed to the last line using leopard crawl as per obstacle 2 above.<br><br>When elbows touch the line, stand up and prepare for the last obstacle. |
| 19. | Barrier 3 (height 4.25 ft or 1.3 m) | Cross obstacle in the same manner as per obstacle 3.<br><br>Time stops when both feet touch the ground. |

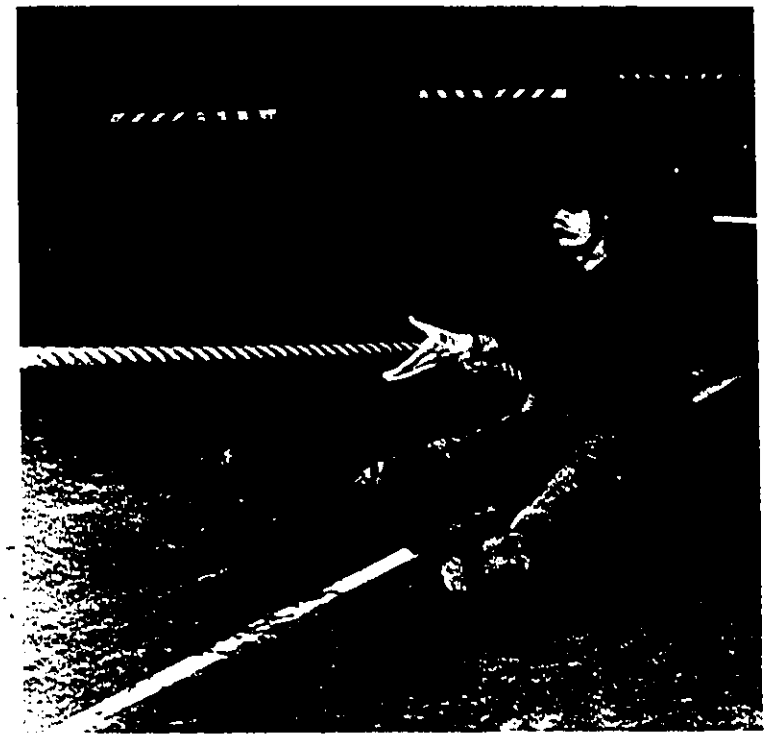
General layout - Cartier Drill Hall

Item 1 - Run 1.5 laps (135m)

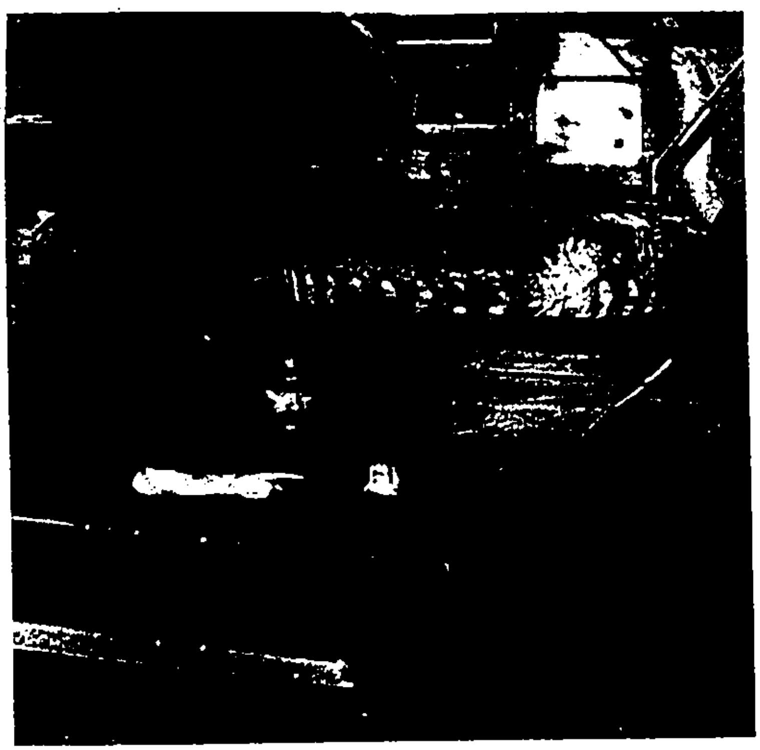
Item 2 - Leopard crawl (9m)



Item 3 - Barrier 1 (1.07m high)



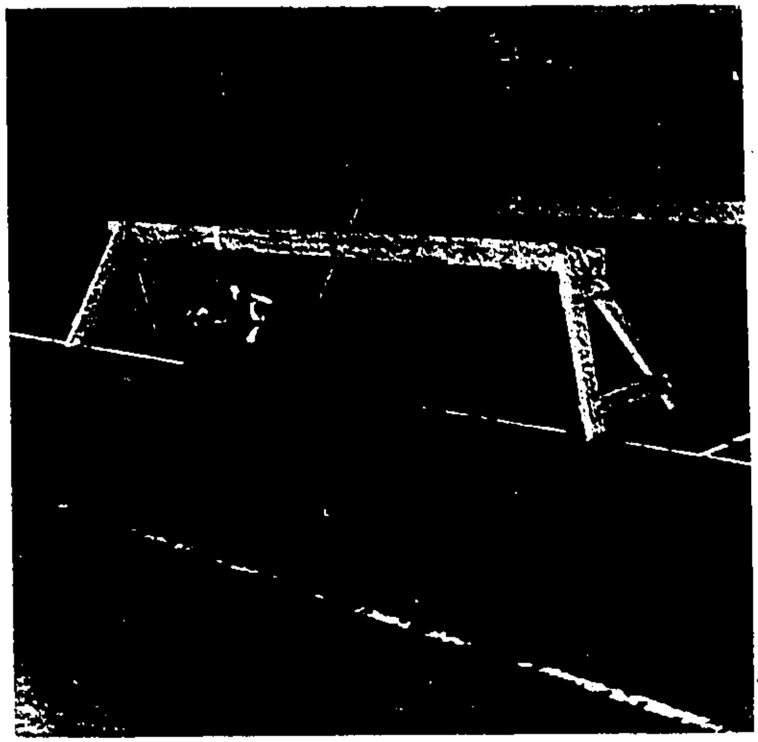
Item 4 - Seated Pull (5m)



Item 5 - Low crawl 1

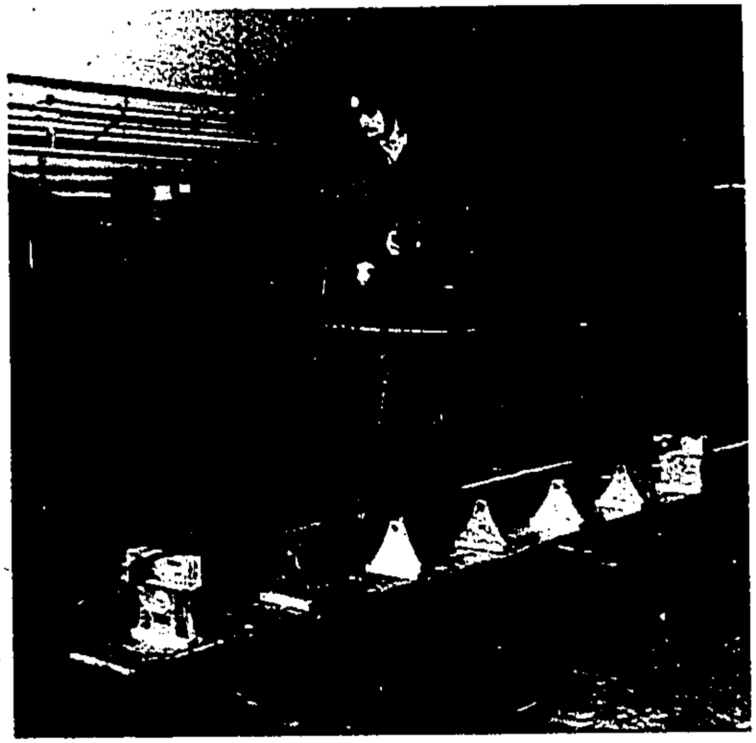
Item 6 - Horizontal ladder traverse (7.3m)
Item 7 - Low crawl 2

Item 8 - Low hurdles (3) (0.76m high)

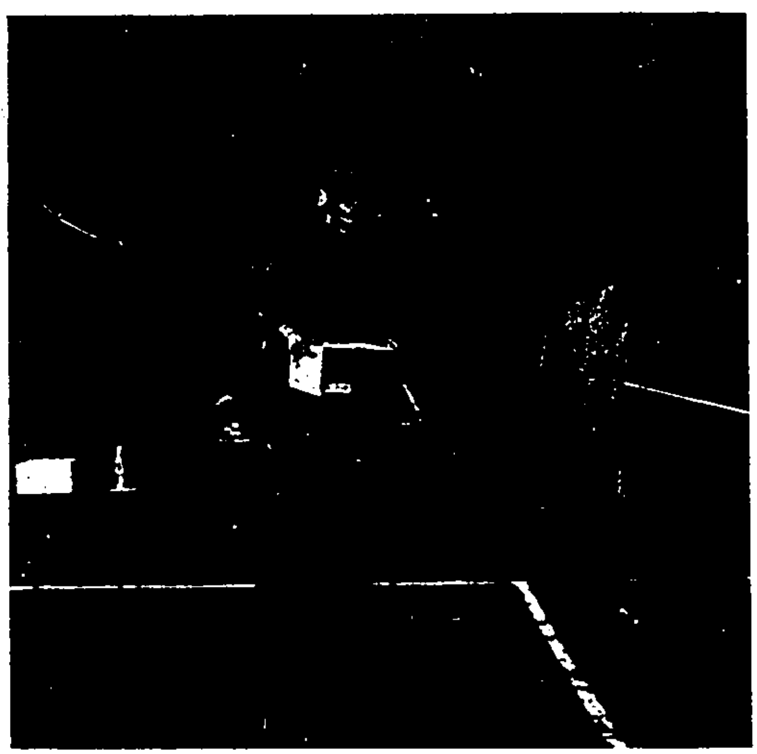


Item 9 - Under/over/under (0.76m high)

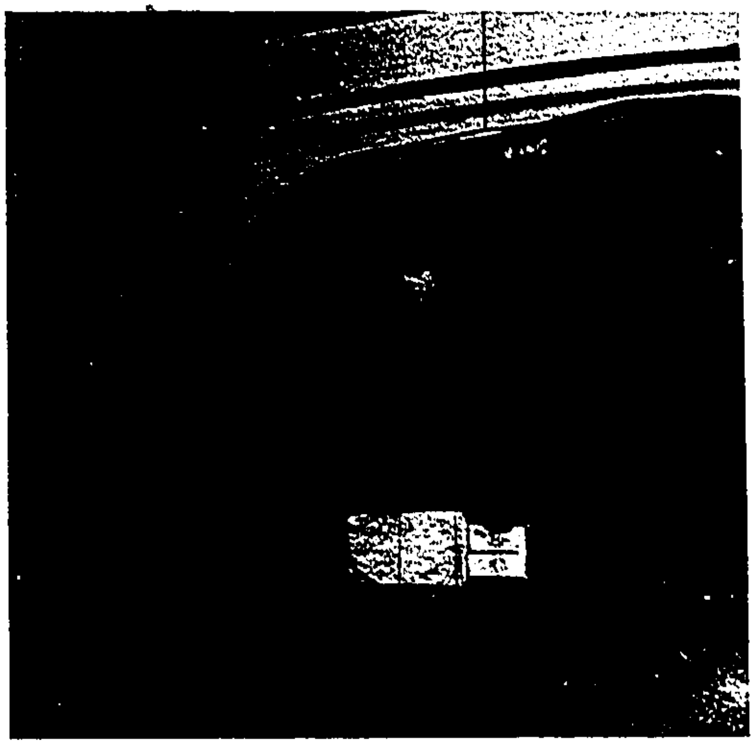
Item 10 - Tire maze (11 tires)



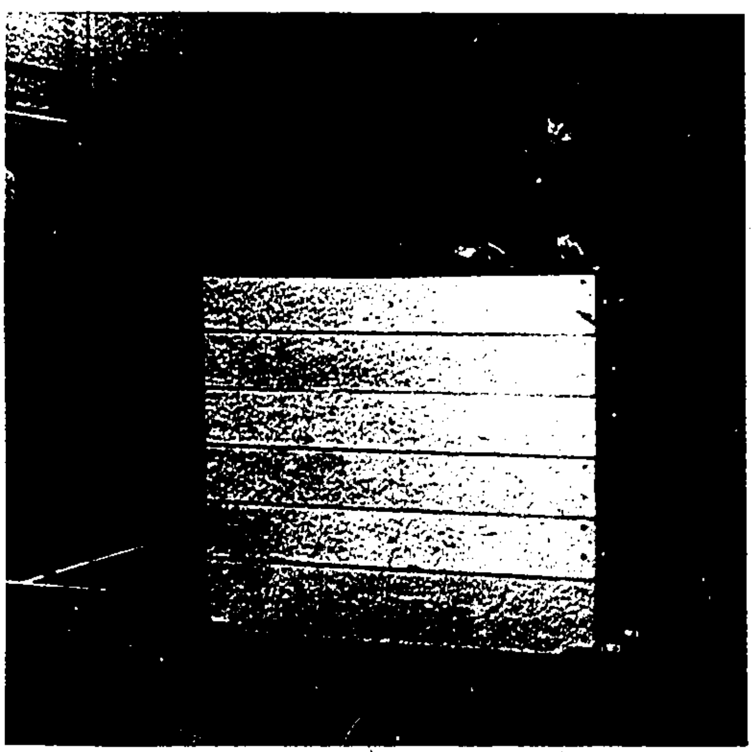
Item 11 - Reversed bench balance (3.66m)



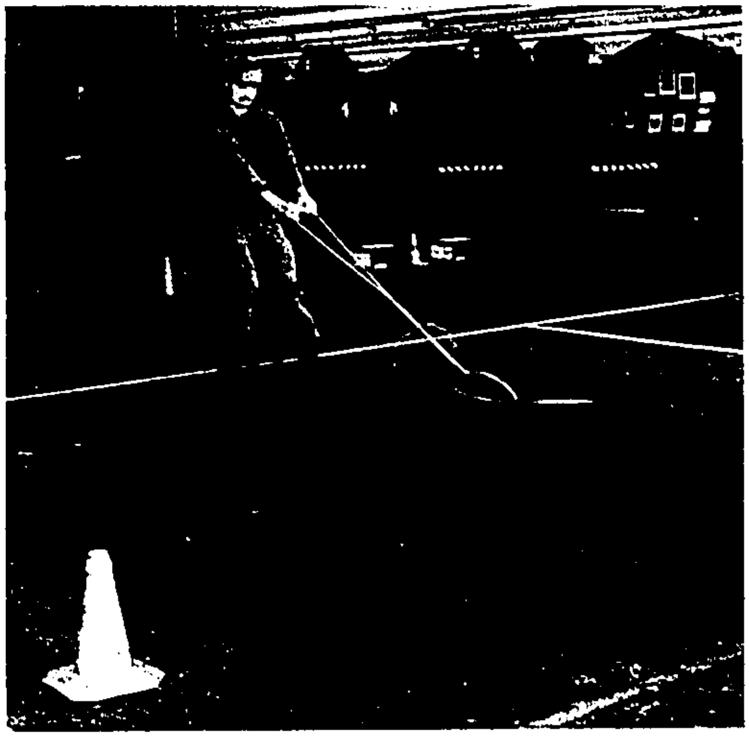
Item 12 - Ammo box lift, carry and load
(26.3kg - 40m)



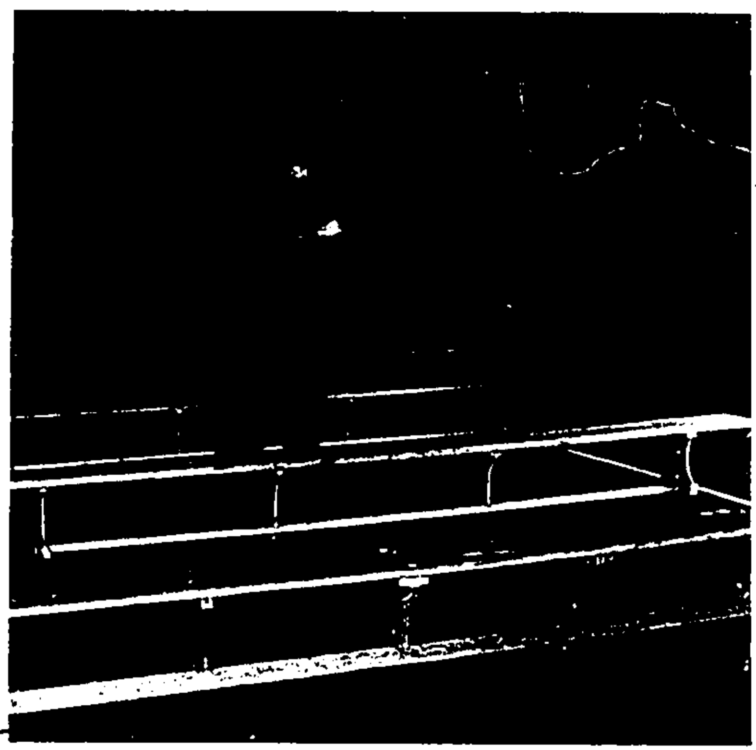
Item 12a - Ammo box load and push



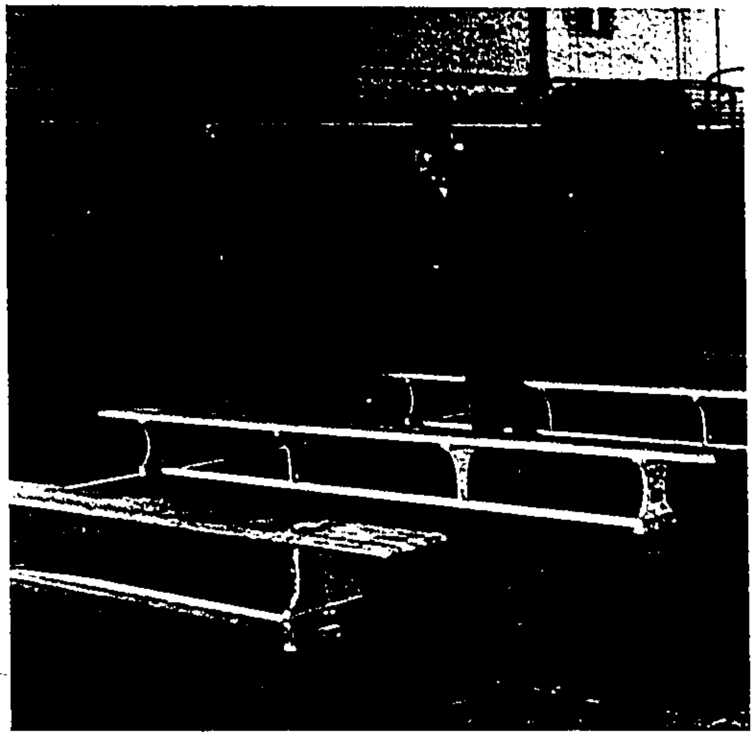
Item 13 - Barrier 2 (1.38m high)



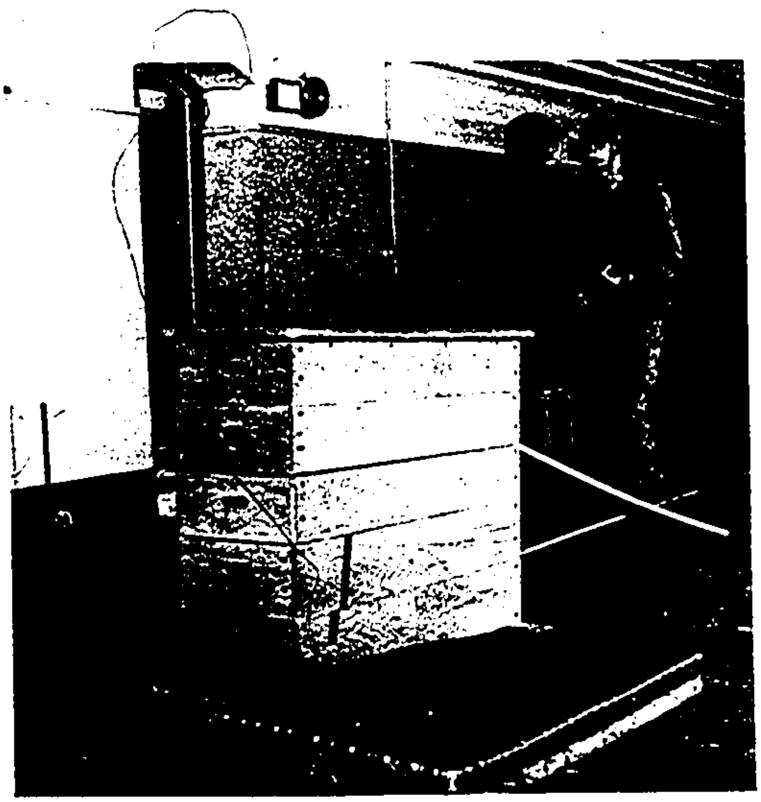
Item 14 - Tire pull (68kg - 16m)



Item 15 - Sand bag lift and carry
(29.5kg - 60m)



Item 16 - Low hurdles (5) (0.3m high)

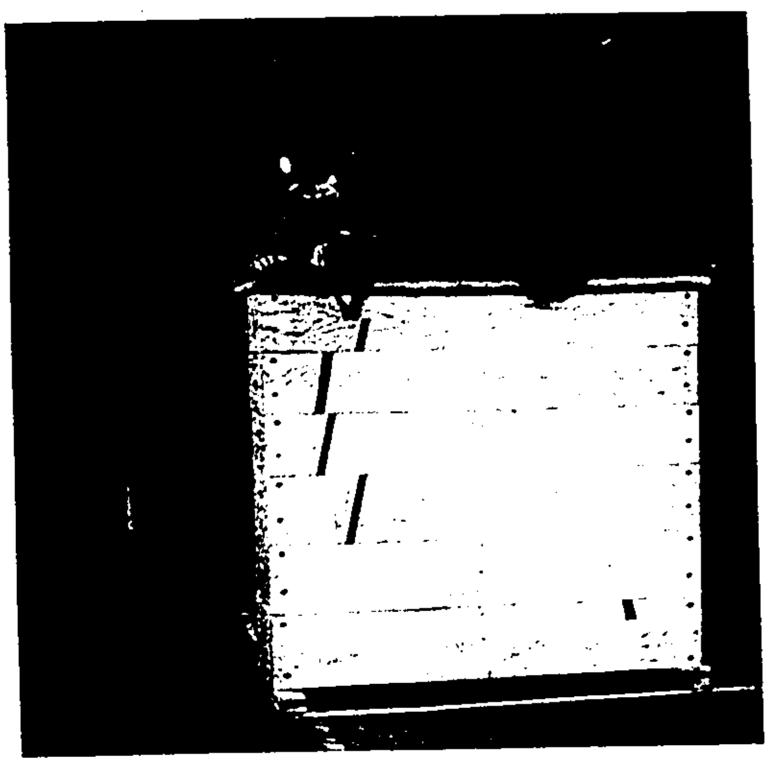


Item 17 - Ramp, run, jump (1.1m high)

Item 17a - Landing

Item 17b - Rolling

Item 18 - Leopard crawl (17m)



Item 19 - Barrier 3 (1.3m)

# APPENDIX A-6

## ISOC EQUIPMENT REQUIREMENTS

## List and Description of Equipment Required for ISOC

| Obstacle | Description of Equipment |
|---|---|
| 1. 1.5 lap run | 4 pylons - place one at each corner of the drill hall - drill hall floor dimensions (18 m x 30 m, plus a border of 2 m) |
| 2. Leopard crawl | 4 mats 8 ft x 4 ft x 1.5 in (2.4 m x 1.2 m x 3.8 cm) with velcro fastenings.<br>. mark a line 1.2 m (half the mat length) from box horse (Barrier 1) with tape |
| 3. Barrier 1 | Box horse - 3.5 ft high (1.07 m) x 4 ft long (1.2 m)<br>. place at end of mat, length parallel to end |
| 4. Seated pull | 1.5 in (or 3.8 cm) diameter rope at least 10 m long<br>. attach to MLVW truck front bumper<br>. mark points 1 m and 6 m from truck with tape, after rope is attached |
| 5. Low crawl 1 | 2 mats (as above)<br>. place under truck, 2 m from rear of front tires |
| 6. Horizontal ladder | 17 ft (5.2 m) 16 round rung aluminium construction ladder<br>. place tape on second rung from both ends<br>. secure to second tarp bow, on the side closest to the front of vehicle<br>2 MLVW trucks |
| 7. Low crawl 2 | 2 mats (as above) |
| 8. Low hurdles | 3 track and field hurdles 2.5 ft (0.76 m) high<br>. place first 4.5 m from truck<br>. interval between hurdles is 3 m |
| 9. Under/over/under | 3 traffic barriers 12 ft long x 2.5 ft high (3.66 m x 0.76 m)<br>2 mats (as above)<br>. barriers are parallel to hurdles<br>. first barrier is placed 4 m from last hurdle<br>. interval between barriers is 2.5 m |

| | |
|---|---|
| | . place a mat under first and third barrier, length parallel to barrier |
| 10. Tire maze | 11 tires<br>. place in two lines as per Figure 2<br>. first tire is 2 m from end line |
| 11. Reversed bench balance | 1 bench 12 ft x 0.75 (3.66 m x 0.23 m)<br>. placed 9 m from end line |
| 12. Ammo box lift | 2, 7.62 mm ammunition boxes reinforced on the inside four corners and filled with sand contained in green plastic bags (weight 58 lb or 26.4 kg). (extra four boxes ready in event of breakage)<br>. place boxes 16 m from end line, side by side, 1 m apart, backs of boxes (no wire fasteners) facing benches. |
| 13. Barrier 2 | Box horse - 4.5 ft (1.38 m) high x 1.5 m long<br>. place 1 m from end line |
| 14. Tire pull | 1 semi trailer truck tire (weight 120 lb or 54.4 kg; 1.8 m in diameter, 0.25 m across the tread, 0.30 m across the sidewall).<br>. add two 15 lb (6.8 kg) sand bags to the inside of the tire - total weight 150 lb or 68 kg<br>. tie a 14 ft (4.27 m), 3/8 in thick (9.5 mm) nylon rope together at the ends. Loop it around the tire giving a length of 4.5 ft (1.37 m) to pull<br>. tape two lines, 8 m apart, the first one 5 m from the end line. |
| 15. Sandbag lift and carry | Triple bag 65 lb (29.5 kg) of sand using a green plastic bag between two standard burlap sand bags<br>. place bag 15 m from end line, marking spot with tape and a pylon<br>. place 5 benches (standard 12 ft or 3.66 m) at distances 2, 4, 6, 8 and 10 m from the end line, the middle of the benches in line with the sand bag |
| 16. Low hurdles | The 5 benches used in obstacle 15 are also used for this obstacle. |

| | |
|---|---|
| 17. Ramp, run jump | 1 box horse - 3.7 ft (1.1 m) in height, 1.5 m long; 1 ramp 8 ft long (2.4 m), 0.75 ft wide (0.23 m) with hooks which attach 0.7 m from the ground on the end of the box horse<br>. place ramp lengthwise, the lower end 3 m from the end line<br>. place 9 velcro fastened mats lengthwise from the jumping edge of the box horse |
| 18. Leopard crawl | Tape last line 4.5 m from last barrier |
| 19. Barrier 3 | 1 box horse - 4.25 ft (1.3 m) high, 1.5 m long, 0.5 m wide<br>. place at the end of the series of mats, perpendicular to the direction of the lane |

## Total Equipment

2 stop watches, each with lap times and digital readouts

1, 50 m cloth measuring tape

17 pylons

3 rolls white cloth tape (0.75 in or 1.9 cm)

19 mats (8 ft x 4 ft x 1.5 in or 2.4 m x 1.2 m x 3.8 cm)

4 box horses (heights 3.5 ft (1.07 m); 4.5 ft (1.38 m); 3.7 ft (1.1 m) with bar to hook ramp at 0.7 m up from ground; 4.25 ft (1.3 m), all 0.5 m wide and 1.5 m long

1 ramp (plank) 2.4 m (8 ft) long, 0.25 m wide and 2.5 cm thick, with two hooks at one end

1, 3.8 cm thick tug-of-war rope at least 10 m long

2,2 m lengths of rope (9.5 mm thick) to secure the ladder

1, 4.27 m length of rope (9.5 mm thick) for the tire pull

2 medium logistics vehicles wheeled (MLVW)

1, 17 ft (5.18 m) heavy duty aluminium ladder with 16 round rungs, 1 ft (0.3 m) apart

3 track and field hurdles

3 traffic barriers (12 ft long x 2.5 ft high or 3.66 m x 0.76 m)

11 used auto or panel truck tires

1 used semi-trailer truck tire (120 lb or 54.4 kg)

6, 12 ft (3.66 m) long benches, 0.75 ft (0.23 m) wide, 1 ft (0.3 m) high

2 (plus 4) 7.62 mm ammunition boxes, reinforced and filled with sand as detailed above

2, 15 lb (6.8 kg) bags of sand (for truck tire)

1 (plus 3) bags of sand (triple packed as detailed above)

12 heavy duty green plastic garbage bags

# APPENDIX A-7

## DETAILED LAYOUT PROCEDURE FOR THE ISOC

## Detailed Layout Procedure for the ISOC

### General

1. Ensure drill hall floor is 34 m x 22 m or larger. Perimeter track is therefore at least 2 m in width. All activity on course takes place within imaginary 1 m boundary of outside track.

2. Reference points and lines are combinations of the four corners A, B, C, D (Figure 2). Depending on how often course is set up, strategic points can be painted, taped, or marked in some way so that time spent measuring distances can be reduced or eliminated.

3. Equipment is placed either "parallel or perpendicular to flow of lane". Flow of lane refers to the direction that the soldier runs in the lane.

4. Side AD is closest to large drill hall doors.

5. The course should be set up the night before it will be used, if strategic markings have not been made. The trucks, at least, should be positioned the night before (to minimize exhaust fumes).

### Specific

1. Set pylon at point A, which is at least 2 m from either wall. Measure and record distances Aa and Aaa (distances to each wall).

2. Measure line AD to be 18 m and set pylon at D, ensuring that Ddd is the same length as Aaa. Measure and record distance Dd.

3. Along AD, set pylons at 1 m, 9 m, 11.5 m, and 17 m.

4. Measure line AB to be 30 m and set pylon at B, ensuring that Bb is same length as Aa. Measure and record distance Bbb.

5. Along AB set pylons at 1 m, 3.4 m, 8 m, and 29 m.

6. Position trucks parallel to AD. Minimize time that trucks burn gasoline and keep large drill hall doors open to assist with ventilation. Roll tarps, clean flatbeds, and at-

tach the ladder to the second tarp bow. The first and last rungs should be touching side walls.

7. Measure line BC to be 18 m and set pylon at C, ensuring that Cc and Ccc are the same as Dd and Bbb respectively.

8. Along BC, set pylons at 1 m, 2.8 m, 8.5 m, 10.5 m, and 17 m.

Lane 1

9. Set and fasten four mats for obstacle 2, the first one placed 1 m from lines AB and BC.

10. Set obstacle 3 (box horse) perpendicular to flow and at end of mats. Place tape line across mat, two sections (1.2 m) from box horse.

11. Set obstacle 4 (seated pull) by typing rope to front bumper of vehicle. Straighten rope and place tape markers on rope at 1 m and 6 m from side of vehicle.

Lane 2

12. Place two mats under both vehicles, 2 m from rear of front tires with 1.2 m (two sections) of mat extending on AD sides of vehicles.

13. Place measuring tape on left side of mat under vehicle 1 and extend to pylon at 2.8 m point on BC. Place first track and field hurdle on CD side of measuring tape at 4.5 m point, second at 7.5 m point, and third at 10.5 m point. Place first traffic barrier at 14.5 m point, second at 17 m, and third at 19.5 m. Place a mat under barriers 1 and 3, perpendicular to flow of lane.

Lane 3

14. Place measuring tape at 8.5 m point on BC and extend to 9 m point on AD. At 2 m, place first auto tire on AB side of measuring tape. Place five more tires in a straight line. On CD side of measuring tape, place remaining five tires, beginning with a tire slightly forward of first tire so that it touches first two tires of AB side.

15. At 9 m, place reversed bench parallel to flow of lane, on AB side of measuring tape.

16. At 16 m, place two ammunition boxes, 0.5 m on either side of measuring tape, with unpainted sides facing BC end (ie., wire fasteners facing the AD end). When measuring tape

is removed, place a pylon midway between boxes.

17. At 29 m, place box horse perpendicular to flow of lane, on CD side of measuring tape.

Lane 4

18. Place measuring tape at 11.5 m point on AD and 10.5 m point on BC. At 5 m and 13 m place a line of tape, perpendicular to flow of lane, on CD side of measuring tape. Place a pylon on AB side of measuring tape at 5 m and 13 m. Place semi-trailer truck tire on BC side of first tape line with rope on the AD side of tire.

19. At 15 m, place pylon and sand bag (65 lb or 29.5 kg) on CD side of measuring tape. At 20 m, 22 m, 24 m, 26 m, and 28 m, on CD side of measuring tape, place benches perpendicular to flow of lane.

Lane 5

20. Place measuring tape at 17 m point on BC and 17 m point on AD. At 3 m, place ramp parallel to flow of lane, on CD side of measuring tape. Attach box horse parallel to flow of lane. Connect nine mats, parallel to flow of lane. Place one tape line across mat at 17 m. Align centre of box on centre of mats, perpendicular to flow of lane.

**Post layout**

1. Place pylons 1 m toward inside of course along AD and BC to designate lanes. They are to be midway between obstacles.

2. Inspect each obstacle for safety and proper alignment.

# APPENDIX B

# FORMS USED

UNIVERSITY OF OTTAWA

DEPARTMENT OF KINANTHROPOLOGY

ISOC PROJECT

Having read and understood the attached description of the project and the tests, I agree to voluntarily participate as a subject. I understand that I may withdraw from any activity or from the project without prejudice. I understand that most of the tests involve a maximal effort and that I will experience a temporary state of exhaustion. There is the possibility of minor scrapes and bruises occurring on the obstacle course.

The results will be confidential and will only be used in calculating statistics. The pictures and videotaping will be used for analysis purposes and no one's identity will be revealed.

____________________ Signature

____________________ Witness

____________________ Date

MJ KIN 1985

4816-2-2 (DPERA)

25 Apr 85

SUBJECT FOR PHYSICAL FITNESS ASSESSMENT

1. As part of my Master's degree at the University of Ottawa, and in conjunction with the Directorate of Physical Education, Recreation and Amenities, I will be undertaking a research project to evaluate an indoor, standardized obstacle course (ISOC). The ISOC may be proposed as a test of physical performance for infantrymen, depending on the results of this study. Specifically, I will examine the relationship of the ISOC to standard laboratory measures of aerobic and anaerobic power, muscular strength and muscular endurance for healthy men under thirty years of age.

2. The tests as described in Annex A, will be conducted in the mornings on different days in May and possibly early June. In addition to your annual EXPRES evaluation, there will be five testing sessions which last from 15 to 60 minutes. The appointment times will be assigned so as to minimize work disruptions. All results will be confidential and will be used in statistical procedures without reference to your name. You will be considered as a volunteer and will be free to withdraw from the testing program at any time, without consequences to your job.

3. Your participation as a subject in this meaningful project is requested. Not only will you be contributing to the improvement of CF fitness evaluation procedures, you will receive valuable personal fitness information. Please advise me if you can or cannot participate. During the day, phone the University at 231-5948 and leave your name, work and phone numbers. You may call me at home (523-3895) between 1800 and 2100 hours. A third method of volunteering is to fill out the form at Annex B and leave it with the NDHQ PERI or Assistant, who conducts your EXPRES test. Should you have any questions, please speak to me.

JAKimick

J.A. Kimick
Captain
231-5948 (W)
523-3895 (H)

ANNEX A
TO 4816-2-2 (DPERA)
DATED 25 APR 85

## TESTS AS PART OF ISOC PROJECT

### A. Anthropometric Measures

PURPOSE: To determine size and proportions of your body.

SPECIFICS:
- ° height, weight
- ° skinfolds - triceps, biceps, subscapular, suprailiac, calf
- ° girths - chest, waist, gluteal, biceps, calf
- ° breaths - humerus, femur

LOCATION: University of Ottawa (U of O), Montpetit Hall, Room 306A

TIME OF TEST: 15 minutes

### B. Muscular Strength and Endurance

PURPOSE: To obtain indications of the capacities you have in these domains.

SPECIFICS:
- ° grip dynamometer
- ° maximum weight for one repetition using the leg and shoulder press stations of the universal weight machines
- ° maximum number of repetitions of 36.3 kg (80 lbs) using the bench press technique on the universal weight machine

LOCATION: U of O

TIME OF TEST: 15 minutes

### C. Aerobic Power

PURPOSE: To determine the maximum amount of oxygen your body can use while walking

SPECIFICS:
- ° pre-exercise blood pressure and heart rate will be taken

ANNEX A
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DATED 25 APR 85

- three electrodes will be attached to your chest to record heart rates
- you will be given instructions on walking on the treadmill and breathing using a mouth piece
- you will practice, rest, then be asked to walk at speeds and inclines which will progressively increase every two minutes, until you cannot maintain the pace (about 15 minutes)
- although you will experience temporary exhaustion, this has very little risk for normal healthy individuals

LOCATION: U of O

TIME OF TEST: 45 minutes

D. Anaerobic Power

PURPOSE: To determine the amount of work you can do in a short period of time. This gives an indication of your capacity to utilize a different energy system, one that does not involve oxygen (as was the case in the aerobic test).

SPECIFICS:

- you will be asked to pedal on a stationary bike, as fast and for as long as you can
- the amount of work done will depend on the resistance setting and the number of revolutions which are completed in the time period
- five minutes before and five minutes after you exercise, a few drops of blood will be taken from the end of one of your fingers. This will be analyzed to determine the amount of lactic acid that is produced as a result of your cycling. The pin prick is virtually painless.

LOCATION: U of O

TIME OF TEST: 15 minutes



.../A-3

ANNEX A
TO 4816-2-2 (DPERA)
DATED 25 APR 85

E. Indoor, Standardized Obstacle Course (ISOC)

PURPOSE: To determine how fast you can negotiate the obstacle course.

SPECIFICS:

- wearing combat pants, shirt, boots and helmet liner and carrying a rifle, you will be instructed on how to negotiate each of the 20 obstacles/typical military tasks
- you will warm-up, then go through the course as quickly as you can
- a video camera with a timing device, as well as a stop watch will be used to record your performance
- the course will be completed three times, separated by at least a 48 hour rest.

LOCATION: Cartier Drill Hall (across Canal from NDHQ Bldg - 101 Col By Drive)

TIME OF TEST: 15 minutes

## TESTING ADVISORY

TO:

FROM: Al Kimick 523-3895 (H) 231-5948(W)

Your testing times are:

| | DATE | TIME | LOCATION | TEST(S) |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |

Please note the following instructions:

1. Do not eat, drink coffee, tea, or beverages containing caffine; or smoke within ONE HOUR of your test session.
2. If you are being tested between 0800 and 1000 hrs, have only a light breakfast.
3. Do not consume any alcoholic beverages or exercise strenuously within 24 HRS of your test session.
4. Dress for laboratory tests is: T-shirt, shorts, socks, clean running shoes. Dress for Cartier Drill Hall is combats (boots, pants, shirt) and properly fitting helmet liner.
5. Bring a towel, soap, and a lock.
6. Please arrive 10-15 minutes prior to your stated test time. When the test is at the University, use the elevator to get to the third floor.

**Physical Activity Readiness Questionnaire (PAR-Q)***

PARTICIPANT IDENTIFICATION

# PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check (√) the ☐ YES or ☐ NO opposite the question if it applies to you.

| YES | NO | |
|---|---|---|
| ☐ | ☐ | 1. Has your doctor ever said you have heart trouble? |
| ☐ | ☐ | 2. Do you frequently have pains in your heart and chest? |
| ☐ | ☐ | 3. Do you often feel faint or have spells of severe dizziness? |
| ☐ | ☐ | 4. Has a doctor ever said your blood pressure was too high? |
| ☐ | ☐ | 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise? |
| ☐ | ☐ | 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to? |
| ☐ | ☐ | 7. Are you over age 65 and not accustomed to vigorous exercise? |

If You Answered

## YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him what questions you answered YES on PAR-Q, or show him your copy.

### programs

After medical evaluation, seek advice from your physician as to your suitability for:

- unrestricted physical activity, probably on a gradually increasing basis.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services.

## NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:

- A GRADUATED EXERCISE PROGRAM - A gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- AN EXERCISE TEST - Simple tests of fitness (such as the Canadian Home Fitness Test) or more complex types may be undertaken if you so desire.

### postpone

If you have a temporary minor illness, such as a common cold.

* Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE) Translation, reproduction and use in its entirety is encouraged. Modifications by written permission only. Not to be used for commercial advertising in order to solicit business from the public
Reference PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

* Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare.

University of Ottawa

Department of Kinanthropology

**ISOC STUDY**

**QUESTIONNAIRE**

Name: ________________________________

1. Are you a member of the
   a) Regular Forces? ________
   b) Reserves? ________
   c) Other? ________

2. How many years have you served in the military?
   _____years

3. Are you now serving, or have you served, in the infantry, armour, or artillery?
   a) yes ______
   b) no ______

4. If yes, number of years served? ______years

5. Approximately how many times have you gone through an obstacle course?
   a) 0 ______
   b) 1 to 10 ______
   c) more than 10 ______

6. Have you cycled on a stationary bike before being tested here?
   a) yes ______
   b) no ______

7. If yes, number of times?
   a) 5 or less ______
   b) more than 5 ______

8. Do you cycle your bike regularly (ie. 2 - 3 times per week)?
   a) yes ______
   b) no ______

9. Have you walked on a treadmill before being tested here?
   a) yes ______
   b) no ______

10. If yes, number of times?
    a) 5 or less ______
    b) more than 5 ______

11. Have you ever lifted weights on a regular basis? (ie. 2 - 3 times per week for at least 5 weeks)?
    a) yes ______
    b) no ______

12. Do you take part in REGULAR physical activity?
    a) yes ______
    b) no ______

If yes, then list type(s), amount weekly, duration, and intensity.

Amount weekly: refers to the number of times activity is done.
Duration: refers to minutes per exercise session.
Intensity: light = slight change above normal state
moderate = perspiration and breathing above normal
heavy = heavy perspiration.

| Activity | Amount weekly | Duration | Intensity |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

13. Are you: a) a smoker? ______
    b) an ex-smoker? ______
    c) a non-smoker? ______

14. If a smoker, number of cigarettes smoked per day?
    a) less than 10 ______
    b) 10 to 20 ______
    c) more than 20 ______

15. Enter number of years as:
    a) a smoker ______
    b) an ex-smoker ______

16. Are you posted this summer?
    a) yes ______
    b) no ______

# APPENDIX C

## CALCULATIONS - ANAEROBIC POWER

## Calculations Used To Derive Anaerobic Power

A. Anaerobic Lactic Power

Given:

a. work = force x distance

b. power = work per unit time

c. a recommended unit for power is a watt (W)

d. 1 W = 6.12 $kpm.min^{-1}$

Calculations:

a. work in one revolution = 5 kp x 6 m
= 30 kpm

b. total work = revs x 30 kpm

c. duration of test was 90 s. Therefore, one must convert the work to 1 min by multiplying the total work by 0.667. Thus,

power = revs x 30 kpm x 0.667
= ___ $kpm.min^{-1}$

d. to convert c. to watts, one must divide the answer by 6.12 $kpm.min^{-1}$

B. Anaerobic Alactic Power

a. Similar to A. above, except that the time in which the work was accomplished was only six seconds. Therefore, to obtain the power for 60 s, one must multiply the result by 10 vice 0.667.