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ABSTRACT

Purpose: Examine the relationship between body mass index (BMI), Waist Circumference (WC), performance in the Canadian Forces (CF) EXPRES test, and the Five Common Tasks (5CT) fitness test for CF members 50-59 years. **Hypothesis**: Increasing BMI and WC are related to lower performance in the EXPRES and 5CT. **Results**: For males (n=127, mean BMI=27.7 kg/m^2(±3.4), mean WC=96.99 cm(±9.8 cm)), increasing BMI and WC correlated ($p < 0.05$) with poorer results on the Land Evacuation, Low High Crawl, Sandbag Carry, VO2max, Push-Ups and Sit-Ups. Performance was significantly worse for males with an "Obese" BMI than other groups and for those with a WC$\geq$102 cm. The results for females (n=27, mean BMI=25.8 kg/m^2(± 3.6), mean WC=84.5 cm(± 9.3 cm)) were inconclusive due to the sample size. **Conclusion**: For males, increasing BMI and WC were related to lower performance on some components of CF physical fitness testing. Additionally, the high percent of "Obese" individuals identifies and an alarming trend towards increased health risk.

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LIST OF ACRONYMS

CF	Canadian Forces
DAOD	Defence Administrative Orders & Directives
5CT	Five Common Tasks
MPFS	minimum physical fitness standards
EXPRES	CF physical fitness test consisting of aerobic capacity test, handgrip strength, push-ups, and sit-ups
MPFS 88	research report completed in 1988 that identified the current CF EXPRES standards
BFOR	Bona fide occupational requirement
CHRA	Canadian Human Rights Act
BMI	body mass index
CAFT	Canadian Aerobic Fitness Test (step test)
HR	heart rate
BP	blood pressure
CBI	Compensation, Benefits & Instructions (policy manual)
WC	Waist Circumference
ECG	Electrocardiogram
VO2max	Maximal Aerobic Capacity
BPM	Beats per minute

CHAPTER 1

INTRODUCTION

1.1 Introduction

The Canadian Forces (CF) has recently undergone a significant transformation. Military members no longer spend entire careers without deployment experience, but are increasingly required to respond to physically strenuous domestic emergencies and international threats, and they are often required to react to these crises with little or no advance warning (Chief-of-Defence-Staff 2006). Additionally, because of changes in modern military devices, such as night vision goggles, Canadian Forces members are often required to perform these military tasks at all hours of the day (Singh 1991), to perform tasks with very little rest, and to perform duties in hostile environments (Knapik, Daniels et al. 1990; Nindl 2002; Castellani, Stulz et al. 2003; Hoyt, Opstad et al. 2006). Specifically, it has been documented that military members must be physically capable of performing operational skills while also possessing the energy reserves to perform cognitive skills such as reading grid maps, to perform skills requiring motor dexterity such as competently handling their weapon, and to function in extremely physically demanding environments such as is required in nuclear, biological and chemical warfare clothing (Knapik, Daniels et al. 1990; Nindl 2002; Castellani, Stulz et al. 2003; Hoyt, Opstad et al. 2006). As a result of this increasing and changing operational role, physical fitness has been identified as an essential and critical component of operational readiness (Chief-of-Defence-Staff 2006) and greater emphasis has been placed on the "Soldier

First" principle (D.A.O.D.-5023-1 8 May 2005; D.A.O.D.-5023-0 2006). The "Soldier First" principle states that:

> *...all CF members, regardless of their age, gender, rank, or military occupation, must be physically fit, employable and deployable to perform general operational duties, common defence duties, and security duties, not just the duties of their military occupation or occupational specification. (1985, c.H-6; CANFORGEN-087/06 2005; D.A.O.D.-5023-0 2006)*

This "Soldier First" principle is outlined in the CF Universality of Service Principle and in the Canadian Human Rights Act and identifies that a CF member may be released from military service for not possessing the physical fitness to complete operational duties. These operational duties are identified as the Five Common tasks which are the following (D.A.O.D.-5023-1 8 May 2005; Stevenson 1988):

1. Land Evacuation – The ability to safely evacuate a casualty on a stretcher over a distance of 1 km;
2. Sea Evacuation – The ability to evacuate a casualty during a fire on board a ship;
3. Low High Crawl – The ability to self-protect when moving in front of enemy fire;
4. Entrenchment Dig – The ability to self-protect in face of enemy fire by digging an entrenchment; and,

5. Sandbag Carry – The ability to self-protect or protect others from natural elements.

These operational tasks are very difficult to test and therefore in 1988 a research study named Minimal Physical Fitness Standards 1988 (MPFS 88) researched and developed a physical fitness evaluation named the Five Common Tasks (5CT) fitness test (Stevenson 1988). In this research study, the laboratory tests that simulated these military tasks were defined and one passing standard for all CF personnel from 17 to 55 years of age was determined. The passing standards for the 5CT are displayed in Table 1.1.

Table 1.1. Passing Criteria for the Five Common Tasks

Land Evacuation (secs)	Sea Evacuation (secs)	Low High Crawl (secs)	Entrenchment Dig (secs)	Sandbag Carry (# moved in 10 min)
900	210	140	510	12

This testing protocol required maximal physical exertion and was considered a maximal fitness test. However, during this time era, the American College of Sports Medicine (ACSM 1985) viewed maximal exercise testing for adults 35 years and older as "risky" and recommended that a physician supervise all maximal testing. The CF did not feel that it was reasonable to have a physician supervise fitness evaluations for all CF members, so a sub-maximal 5CT standard was also developed.

The sub-maximal 5CT protocol limited participants to an exertional effort that was less than 90% of their age predicted heart rate maximum (HRmax); thereby allowing CF members aged 35 to 55 years to attempt the 5CT without the presence of a physician. These older CF personnel were required to wear a heart rate monitor that provided an audible alarm when they exceeded their age specific 90% HR limit. When the alarm sounded, the participant was required to stop movement and rest in place until the alarm ceased. When the alarm ceased, the participants were permitted to continue performing the task. This age specific HR limit was determined by using the following formula where a standard resting HR value of 70 beats•min^{-1} was used:

$$90\%\ HR_{max} = 0.9\ ((220\text{-}age) - HR_{rest)} + HR_{rest} \ldots\ldots\ldots\ldots \quad (1)$$

The passing standards for both the maximal and sub-maximal protocols are displayed in Table 1.2.

Table 1.2. Age Specific Passing Criteria for the Five Common Tasks

Protocol	Land Evacuation (secs)	Sea Evacuation (secs)	Low High Crawl (secs)	Entrenchment Dig (secs)	Sandbag Carry (# moved in 10 min)
"Gold Standard" < 35 years or maximal protocol for personnel 35-55 years exertion with physician supervision	900	210	140	510	12
Sub-maximal protocol for personnel 35 -55 years	1188	277	185	673	9

The 5CT is the "Gold Standard" fitness test for the CF. This test requires but requires two and a half days of testing, extensive amounts of equipment, and also a high participant to evaluator ratio. As a result, an alternative fitness test, known as the CF EXPRES test was also developed. The CF EXPRES test is a Fitness Component test (Bonneau 2000) that was designed to evaluate the components of physical fitness required to successfully complete the 5CT, which are evaluations for aerobic capacity, muscular strength, and muscular endurance. The MPFS 88 (Stevenson 1988) research study also identified that the fitness capabilities required to complete the 5CT differed greatly between the age categories and also between the genders and consequently four different age and gender performance categories were developed. Specifically, the MPFS for the CF EXPRES test were developed for males under 35 years, females under 35 year, males 35-55 years, and females 35-55 years. This passing standard was known as the Minimum Physical Fitness Standard (MPFS) (Stevenson 1988).

The passing standards for the 5CT and the MPFS for the CF EXPRES test that were identified in MPFS 88 have been used exclusively as the standard for CF fitness evaluations. However, in 2004 the CF extended the compulsory retirement age for CF members from age 55 to age 60 and thus it became necessary to conduct research to determine appropriate physical fitness standards for CF personnel within this age group. Additionally, because MPFS 88 included only five males and no females over the age of 50, it was decided that supplementary research was required to validate the current performance standards for CF members 50 years of age and older (Stevenson 1988). Therefore, in 2005 a new research study titled MPFS for CF members 50 years and older was initiated (Lee, Flanagan et al. 2007).

The MPFS 50 years and older research study attempted to set MPFS for the 5CT and for the CF EXPRES test by replicating the methodology used in MPFS 88. Surprisingly, due to the physical condition of the CF personnel who participated in this research study, it was not possible to set MPFS (Lee, Flanagan et al. 2007). This research study identified that only 48 personnel or 41.7% (mean (SD) = 52.2 (1.96)) of the 115 participants aged 50 to 55 years of age who participated in the study successfully met the 35 to 55 year old standard for the 5CT many CF personnel. Additionally, only 55% of the participants (n=25) who completed the maximal protocol met the maximal passing criteria for the 5CT. Specifically, 22 of the male subjects (50% of participants, mean (±SD) age = 54 (3), range: 50 to 59 years) and none of 3 participating females (mean± age 51 (1.0), range 50 to 52 years) who performed the maximal protocol met the minimum (Lee, Flanagan et al. 2007).

The MPFS 50 years and older research study identified that the physical performance of CF members 50 years and older was insufficient to allow the development of a 5CT physical fitness standard for this age group. However, this report did not examine possible causes for decrements in performance nor did the report examine the relationships between performance on the 5CT and the health or fitness of the participants. For example, the relationships between anthropometric measurements such as Body Mass Index (BMI) (calculated as weight in kilograms divided by the square of height in meters) waist circumference (WC) and performance were not examined. These evaluations are particularly important in determining health risk status.

A very large study by the National Institute for Health (NIH) (n= 14924) identified that health risk significantly increased as BMI increased above 25 kg/m^2 , when WC was greater than or equal to 102 cm for males and 88 cm for females, and that health risk was highest when these two variables were evaluated in combination (i.e. high BMI and high WC) (Janssen, Katzmarzyk et al. 2002). Therefore, if the health risk status and the relationship between health risk status and performance in the 5CT is examined, it may be possible to identify anthropometric profiles of CF members aged 50 to 59 years that are associated with successful performance in the 5CT as well as identify anthropometric profiles that are associated with lower likelihood of successful 5CT performance.

To date, there is limited, published research regarding the physical fitness of CF members (Jette and Sidney 1990; Stevenson 1992; Stevenson 1994). There has been a few internal reports prepared for the CF regarding the physical fitness and anthropometric profiles of their members, but most were generated via self-reported questionnaires of (CF-Health-Services-Group 2002; Directorate-of-Force-Health-Protection-CF-Health-Services-Group 2005; Health-Canada 2005). There has not yet been an evaluation of the physical fitness of CF members 55 to 60 years of age nor has any study examined the relationship between anthropometric measurements (i.e BMI and WC) and performance in the 5CT or in the CF EXPRES test. Therefore, because of the increased emphasis on the "Soldier First" principle, which emphasizes that all CF personnel must be operationally and physically fit, it is important to determine a.) how anthropometric profiles (i.e. BMI, WC, and the combination of BMI and WC) are related to performance on the CF's occupational fitness test, the 5CT b.) how the physical fitness of the CF members 50 to 59 years of age is related to performance on the 5CT and c.) if the physical fitness and health risk status, as identified by BMI and WC, for this older group of CF members is comparable to data for younger CF members.

1.2 Objective

The primary objective of this study was to provide a profile of the physical fitness and anthropomentric profile of mature CF personnel aged 50 to 59 years. Physical performance was assessed using the CF EXPRES test and the 5CT occupational fitness test. Additionally, the study examined the relationship between anthropometric measurements and physiological components of fitness as measured in the CF EXPRES test and physical performance on the 5CT (Land Evacuation, Sea Evacuation, Low High Crawl, Entrenchment Dig, and Sandbag Carry). Finally, the study compared the anthropometric profile of mature CF members 50 Years and older to Canadian population norms for similar age groups to determine if this CF population is representative of the Canadian norms for this age group. The CF members aged 50 to 59 years were also compared to previous published and un-published data for younger CF members to determine if there are observable differences between various age groups within the CF.

1.3 Hypothesis

The following hypotheses were examined:

1. Increasing BMI in CF personnel aged 50 to 59 years is associated with increasingly poorer performance on each of the 5CT and on all components of the CF EXPRES test.
2. CF males aged 50 to 59 years with a WC greater than or equal to 102 cm (e.g. NIH WC higher health risk classification) and CF females of the same age group with a WC greater than or equal to 88 cm (High WC group) demonstrate poorer performance on the 5CT fitness test and CF EXPRES test than males who have a WC less than 102 cm (Low WC classification) and females who have a WC less than 88cm (Low WC classification).
3. CF members aged 50 to 59 with a BMI that falls within the NIH BMI "overweight" or "obese" classification, combined with the higher WC

classification are associated with the poorest performance in both the 5CT and the CF EXPRES test.

4. Lower aerobic capacity, muscular strength, and muscular endurance as measured in the CF EXPRES test are associated with poorer performance in the 5CT for CF members aged 50 to 59 years.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

All Canadian Forces members are "Soldiers First" (8 May 2005). All members, regardless of their individual military occupation, trade, sex, or rank classification must possess the physical fitness to perform emergency military tasks, to protect oneself, and to also protect the lives of others(D.A.O.D.-5023-0 2006). Additionally, the Canadian Human Rights Act (CHRA) (1985, c.H-6), paragraph 15 (9)(8 May 2005) identifies the unique nature of the CF and states in the Universality of Service for Canadian Forces:

> *"CF members must at all times and under any circumstances perform any functions that they may be required to perform, and they must be physically fit to meet military operational requirements"(8 May 2005; 1985, c.H-6).*

The physical demands of these operations may be very diverse and therefore the CHRA also indicates that CF personnel may be released from service should they be unable to meet the minimum physical fitness standards requirements that are required for the safe and effective performance of their occupation. However, these physical fitness standards must meet the criteria of a bona fide occupational requirement (BFOR) (1985, c.H-6).

2.2 Bona Fide Occupational Requirements

A bona fide occupational requirement is defined as a condition of employment that is enforced in the belief that it is essential for the safe, efficient, and reliable performance of a job (1988). An occupational physical fitness standard can only be classified as a BFOR if the employer can establish that individual(s) needs cannot be accommodated without causing undue hardship to the health, safety or cost for the person who would have to accommodate those needs (1985, c.H-6). If the employer is able to meet the expectations for a BFOR, the CHRA states that it is not a discriminatory practice to release an individual from employment for failure to meet the physical demands (1985, c.H-6).

The term "bona fide occupational requirement" was first identified in the 1977 inauguration of the CHRA, but since that time, the laws and definitions regarding BFOR have undergone significant changes (2007). Specifically, one of the greatest developments in BFOR was the 1999 Supreme Court ruling in The Meiorin case: British Columbia (Public Service Employee Relations Commission) v. British Columbia Government and Service Employees' Union. This case dealt with a grievance by a female forest firefighter, Ms. Tawney Meoirin, who was dismissed from her job because she failed one aspect of the minimum fitness standard. Ms. Moeirin challenged that the aerobic fitness standard, as established by the Government of British Columbia for all firefighters, unfairly discriminated against females. Furthermore, she challenged that her low aerobic capacity did not prevent or limit her job success as she was able to meet all of the job demands for the previous three years (1999).

Ms. Meoirin successfully won her case as the Supreme Court of Canada ruled that the aerobic standard was not a valid BFOR. However, this case was particularly influential as this Supreme Court ruling provided clearly defined criteria for a BFOR. The Court ruled that:

> *For any practice related to paragraph (1) (a) (refusal, exclusion, expulsion, suspension, limitation, specification or preference in relation to any employment) to be considered to be based on a bona fide occupational requirement..... it must be established that accommodation of the needs of an individual or a class of individuals affected would impose undue hardship on the person who would have to accommodate those needs, considering health, safety and cost (1985, c.H-6).*

The court also established that employers have the responsibility to ensure that occupational standards are rationally connected to the performance of the job and that these standards must be imposed with honesty and good faith, in the belief that they are necessary for job performance (2007).

This 1999 Supreme Court ruling was the first documented legal approach for developing BFORs. Therefore, in 2000 a group of Canadian scientific researchers participated in a Consensus Forum to establish a set of scientific guiding principles for developing BFOR for physically demanding professions (2000). These researchers examined earlier scientific studies to identify the key steps in developing occupational physical fitness standards. The forum came to a consensus and the following steps were recommended:

1. Justify the need for a BFOR and define the underlying issues. Employer must identify the decision to have a BFOR and identify the reasons why they want/need this standard. The BFOR must be relevant to job safety and the employer must be able to identify what situations or changes in the workplace have made this standard necessary. This process should involve all stake holders that should include subject matter experts, scientific experts, legal council, human resource personnel, union representatives, etc.

2. Job Familiarization and Physical Demands Analysis. A comprehensive list of important, physically demanding tasks encountered on the job should be developed by job observation, review of incident reports, and review of literature pertaining to the job. It is imperative the job requirements are observed in all environments. The list should then be summarized to develop an employee rank-ordered list of physically demanding tasks that identify the importance, extent of physical demands and the frequency of occurrence.

3. Identify and characterize a subset of physically demanding tasks. Tasks that are critical for saving lives or property under emergency conditions should be characterized. Whenever possible, this characterization should be conducted under "live" job conditions and should include weighing equipment, determining heights of lifts and the forces involved, determining time constraints, identifying

environmental conditions and the identifying and measuring physiological responses to each task (i.e. heart rate, aerobic demands, rate of perceived exertion, etc). The performance of these tasks must not be skill dependent or have a learning factor and they must be able to be measured objectively and reasonably.

4. Develop a standardized testing protocol based upon the representative tasks and determine the scientific accuracy of the testing protocol. A testing protocol must be developed from the subset of physically demanding tasks that reliably and validly compares to the physical / physiological characteristic of the job tasks. This protocol must be able to be administered objectively, reasonably, and should not include testing items that require training.

5. Determine performance standards. The pass/fail cut-off scores must be based on a demographically representative sample or from a sub-group of the workforce with the lowest physical performance scores. However, the employer must ensure that due diligence is used when applying this standard as every employee must be capable of rescuing co-workers or the public under life threatening conditions.

6. Implement and evaluate the performance standards and testing protocol. The performance standard should first be implemented with a small representative employee sample to evaluate the impact of implementing the standard. If it is

believed there will be an adverse impact on any demographic constituents (i.e. gender, age, ethnic groups) the BFOR must be justified, adjusted, or re-examined.

7. Maintain an on-going review. Test results should be analysed for ongoing re-affirmation of the performance standards, for changes in workplace practises, technological advances, and government / court decisions(2000).

2.3 CF Development of Occupationally Relevant Fitness Test

Although these steps to develop an occupational fitness test were only identified in 2000, the underlying principles were used to develop physical fitness standards for the CF as early as 1983. Specifically, in late 1983, CF experts at National Defence Headquarters, commenced the process of identifying occupationally relevant physical fitness standards and developing an occupationally relevant fitness test for the CF. These experts felt that the generic nature of the 1983 version of the CF EXPRES test that was based on the Canadian Standardized Test of Fitness (1986) (a Canadian Aerobic Fitness Test (CAFT) step test, handgrip strength, maximum number of push ups, and maximum number of sit-ups in one minute) provided the CF member with general knowledge of his/her physical fitness as compared to other Canadians, but that that this test did not relate or test the physical abilities to perform military duties and tasks. Therefore, the CF experts commenced a physical demands analysis.

2.3.1 Review the Job and Conduct a Physical Demands Analysis

From 1983 to 1988, CF experts with the support of physical educators in the Department of Physical Education, Recreation and Amenities studied and discussed occupational exposures of CF members during the Cold War era (Stevenson 1988). These experts identified seven common tasks that all CF members would be expected to perform in time of emergency. These tasks were identified as:

1. Operate one's personal weapon (shoot to live);
2. Function effectively in a nuclear, biological, chemical warfare (NBCW) clothing environment;
3. Perform first aid and casualty evacuation from land and sea;
4. Perform firefighting duty;
5. Execute survival Search and Rescue Techniques; and,
6. Perform General Security Duties:
    i. March 8 km
    ii. Entrenchment Dig
    iii. Lift and Carry Sandbags
    iv. Low and High Crawl
    v. Rush and shoot with weapon
7. Live and work in NBCW clothing as applied to condition 6 (Stevenson 1988).

2.3.2 Identify and characterize a subset of physically demanding tasks

These seven common tasks involved both military skill and physical components and not all components involved a high physical fitness component. Additionally, the physical demands of some tasks, such as living and working in a nuclear, biological, chemical warfare environment, were considered too complex for evaluation. Therefore, a selection of five tasks were identified as the subset of physically demanding tasks that any soldier, seaperson, or airperson could reasonably be expected to experience and/or to respond (Stevenson 1988). These five common physically demanding tasks were defined as the following (Stevenson 1988):

1. Land Evacuation – The ability to safely evacuate a casualty on a stretcher over a distance of 1 km;
2. Sea Evacuation – The ability to evacuate a casualty during a fire on board a ship;
3. Low High Crawl – The ability to self-protect when moving in front of enemy fire;
4. Entrenchment Dig – The ability to self-protect in face of enemy fire by digging an entrenchment; and,
5. Sandbag Carry – The ability to self-protect or protect others from natural elements.

2.3.3. Develop a standardized test protocol based upon the representative tasks and determine the scientific accuracy of the testing protocol

The five common physically demanding tasks were then analysed and researched during the MPFS 88 (Minimal Performance Fitness Score) research project so that a standardized laboratory testing protocol could be developed. This standardization process was lengthy and rather complex as all tasks had to be adjusted to allow one-person testing (i.e. the land and sea evacuation were restructured with wheels on the stretchers) while other tests required alteration to ensure standardization for all personnel (i.e. the entrenchment dig became a task of removing crushed rock from one box to another). Each test underwent repeatability testing and the Pearson correlation coefficients for test-retest scores for each testing component ranged between r= .93 to r= .99 (Stevenson 1988). The result of these repeatability and standardization studies was the development of an indoor fitness test called the 5CT, which consisted of the following:

1. Land Evacuation. This task was designed to simulate a land evacuation of a casualty on a stretcher over a distance 1 km. Participants in this task carried half of an 80 kg mass on a normal stretcher with wheels attached to one end, as quickly as possible over a distance of 750 m. Time is recorded in seconds. (The 1 km distance was reduced to 750 m as the correlation coefficient was r=.94 between the times for these distances.)

2. Sea Evacuation. This task simulated a casualty evacuation during a fire on board ship. In this task participants are fully clothed in firefighter clothing consisting of a coat, pants, boots, gloves, and suspenders. They then lifted and carry one end of an 80 kg Stoker Stretcher a distance of 25 m where they then moved to a Shipboard simulator (a replication of a flight of Ship stairs that are 3 m in height set at a 60° from the horizontal) and proceeded alone carrying the equivalent weight and stretcher to the top of the Shipboard

Simulator stairs. Participants were then required to take a mandatory 5 second safety pause at the top of the stairs before returning to the starting line. Time was recorded in seconds.

3. Low High Crawl. This task simulated conditions of self protection when moving in front of enemy fire. The crawl is performed in full combat clothing including helmet, fatigues, and while carrying a rubber C7 rifle (approximately 3.3 kg) over a firm, yet soft, 2 m wide rubberized runway. The test required that participants move through a 75 m course by performing a 30 m low (leopard) crawl under 16 barriers (45 cm height, 180 cm width) at 2 m intervals and then return a distance of 45 m while performing a high (kitten) crawl on their hands and knees. Time is recorded in seconds.

4. Entrenchment Dig. This task was intended to simulate self-protection in face of enemy fire by digging and entrenchment. Participants in this task are required to dig gravel (3/8 inch chips or pea stone) using a shovel and their hands to empty a wooden 1.8 m x 0.6 m x 0.45 m box containing finely crushed and slightly moistened rock (to prevent excessive dust). The rocks will be emptied to an identical, empty box until there is less than one shovel full left in the box. Time is recorded in seconds.

5. Sandbag Carry. This task was designed to simulate self-protection or protection of others from natural elements. Participants lift and carry a 20 kg

sandbag a distance of 50 m, place it on the ground, and return to the start point (50 m away). This process is repeated for a 10-minute period. The total number of sandbags moved is recorded and each additional 10 m is awarded a 0.1 score.

2.3.4 Determine Performance Standards

Once the protocols for the 5CT fitness test was standardized and accepted as a reasonable replication of field tasks, then performance standards were set. This process involved the fitness evaluation of 71 males under age years of age 35 (mean (±SD) 24 (6), range: 17 to 34 years), 59 females under 35 years of age (mean (±SD) 26 (4), range: 18 to 34 years) , 62 males aged 35 years and older (mean (±SD) 43 (5), range: 35 to 53 years), and 28 females aged 35 years and older (mean (±SD) 38 (2), range: 35 to 44 years) (Stevenson 1986; Stevenson 1988). All personnel were requested to attempt the tasks and then a cross section of an evenly distributed, representative number of men and women were selected for evaluation. In order to comply with the Charter of Human Rights, a common pass/fail criterion was established for all groups that corresponded to the 75th percentile of the sample population. From this analysis, the 5CT passing standards as displayed in Table 2.1 were developed.

Table 2.1. Passing Criteria for the Five Common Tasks

Land Evacuation (secs)	Sea Evacuation (secs)	Low High Crawl (secs)	Entrenchment Dig (secs)	Sandbag Carry (# moved in 10 min)
900	210	140	510	12

However, during the completion of the research project, the American College of Sports Medicine (1985) viewed maximal exercise testing for adults 35 years and older as "risky" and recommended that a physician supervise all maximal testing. This recommendation had severe implications for the CF as it was not feasible to have a physician present during all fitness testing. Therefore, it was decided that a sub-study would be conducted to develop a predictive sub-maximal 5CT testing protocol for CF members 35 to 55 years of age.

2.3.5 Develop a sub-maximal standard for personnel 35 to 55 years of age.

The sub-study consisted of 16 males with a mean age of 40.9 years and 3 females with a mean age of 39.7 years. Participants in this sub-study performed the following:

1. A maximal treadmill test to determine maximum aerobic capacity and true heart rate maximum (HR_{max});
2. An Entrenchment Dig test without limitations (i.e. 100% effort);
3. A sub-maximal 5CT protocol where participants were limited to an exertional effort that was less than 90% of their age predicted heart rate maximum. The participants were required to wear a heart rate monitor that provided an audible alarm when they exceeded their age specific 90% HR limit. When the alarm sounded, the participant was required to stop movement and rest in place until the alarm ceased. When the alarm ceased, the participants were permitted to continue performing the task. This age specific HR limit was determined by using the following formula where a standard resting HR value of 70 beats•min^{-1} was used:

$$90\%\ HR_{max} = 0.9\ ((220\text{-}age) - HR_{rest}) + HR_{rest} \quad (1)$$

This sub-maximal research found that Entrenchment Dig Scores improved an average of 36.2% for males and 32.3 % for the females when the heart rate restriction was removed (i.e. 100% effort). Thus, it was decided that a 32% time increase would be appropriate when performing this sub maximal protocol. However, this 32% time increase was also applied to the Land Evacuation, Sea Evacuation, Entrenchment Dig, and Low High Crawl while the passing standard for the Sandbag Carry was decreased by 25%. The passing criteria for completion of the 5CT for CF members younger than 35 years (maximal) and for CF members 35 years and older are displayed in Table 2.2.

Table 2.2. Age Specific Passing Criteria for the Five Common Tasks

AGE	Land Evacuation (secs)	Sea Evacuation (secs)	Low High Crawl (secs)	Entrenchment Dig (secs)	Sandbag Carry (# moved in 10 min)
< 35 Years	900	210	140	510	12
35 Years and Older	1188	277	185	673	9

Unfortunately, the Five Common Task protocol was determined to be too time consuming and logistically difficult to administer to all CF members on an annual basis. Therefore, it was determined that a fitness component test should be developed and that the standards of this test should be set at a limit that would predict successful completion of the 5CT passing standards.

2.3.6 Develop an alternative fitness component test

The MPFS 88 research study also focused on identifying the key physiological components of fitness that were essential for successful completion of the 5CT. The Canadian Aerobic Fitness Step Test (CAFT), a maximum combined handgrip test, maximum number of toe-fulcrum push-ups, maximum number of full sit ups in one minute as well as a Flexed Arm Hang, Endurance Grip, and Freestyle Incremental Lift were chosen to determine which, if any, of these laboratory tests correlated with successful 5CT performance.

The MPFS 88 study identified that aerobic capacity as measured by the CAFT step test, muscular strength as determined by push-ups and handgrip strength, and muscular endurance as determined by the sit-ups test, were the element of fitness that were required for successfully completing the 5CT. However, this research also discovered that there were significant differences in the strategy used to complete tasks and that there were differences in the physiological system used to complete the tasks for males and females. Specifically, as Table 2.3 demonstrates, the fitness component results for males and females 35 years and older as well as for females under 35 years were analysed and compared by using discriminant analysis, simple correlations, and stepwise multiple regression to determine their relationship with each of the 5CT. Analysis was also conducted to determine the fitness components that demonstrated a significant difference between the means of the passing and failing groups.

This research found that the strength of the fitness parameters that predicted successful completion of the 5CT differed significantly between the genders and that one common fitness standard could not describe all ages and sex. Consequently, it was deemed reasonable to have sex and age specific standards for this fitness component test, the CF EXPRES test. The justification for these age- and sex-dependent norms were proposed based upon the following justifications:

1. Biomechanically, it was observed that the tasks were performed differently between the groups;
2. Older participants were restrained to 90% of their age predicted HR_{max};
3. The strength differences on maximal hand grip scores were closely related to body size and thus the differences in grip scores between males and females were more marked than for sit-ups and push-ups; and,
4. The fitness variables underlying task performance differed between the three groups, with particular differences between males and females (Stevenson 1988).

The fitness standards for the CF EXPRES test were then set at a limit that was defined as the minimum physical fitness standard (MPFS). This standard can be explained as "the lowest possible fitness level at which an individual may be reasonably expected to successfully undertake standing orders" (Stevenson 1988). A total of and 59 females under 35 years of age (mean (±SD) 26 (4), range: 18 to 34 years), 62 males aged 35 years and older (mean (±SD) 43 (5), range: 35 to 53 years) , 28 females aged 35 years and older (mean (±SD) 38 (2), range: 35 to 44 years) , participated in the phase III of the MPFS 88 research study, which developed and recommended MPFS for these age groups. Additionally, the results of 71 males (mean (±SD) 24 (6), range: 17 to 34 years), under age years of age 35 who participated in phase II of the MPFS 88 were analyzed to determine standards for their age and gender category (Stevenson 1986). (Phase II had additional fitness component tests of leg and arm ergometry, but no significant relationship was found between these tests and 5CT performance and therefore these fitness component tests were eliminated in phase III.)

The MPFS for the CF EXPRES test were set using the methodology outlined in Figure 2.1 Flow Diagram for the Development of MPFS (Stevenson 1986; Stevenson 1988; Stevenson 1994). First, task scores were rescaled by the most appropriate transformation to achieve approximate normality and equality of variance. EXPRES scores were mean centered for purposes of regression analyses. Pearson correlation coefficients were then computed for performance measure and EXPRES test scores for each gender at a significance of .001 (because of the high number of variables). Backward stepwise regressions were used to investigate the dependence of transformed tasks based on EXPRES for each gender. A cumulative frequency distribution was created by sex and task and the cutting scores were placed at the 75th percentile. Finally, to accommodate the unequal sample sizes between males and females weighted scores were used to establish the passing criterion for each task.

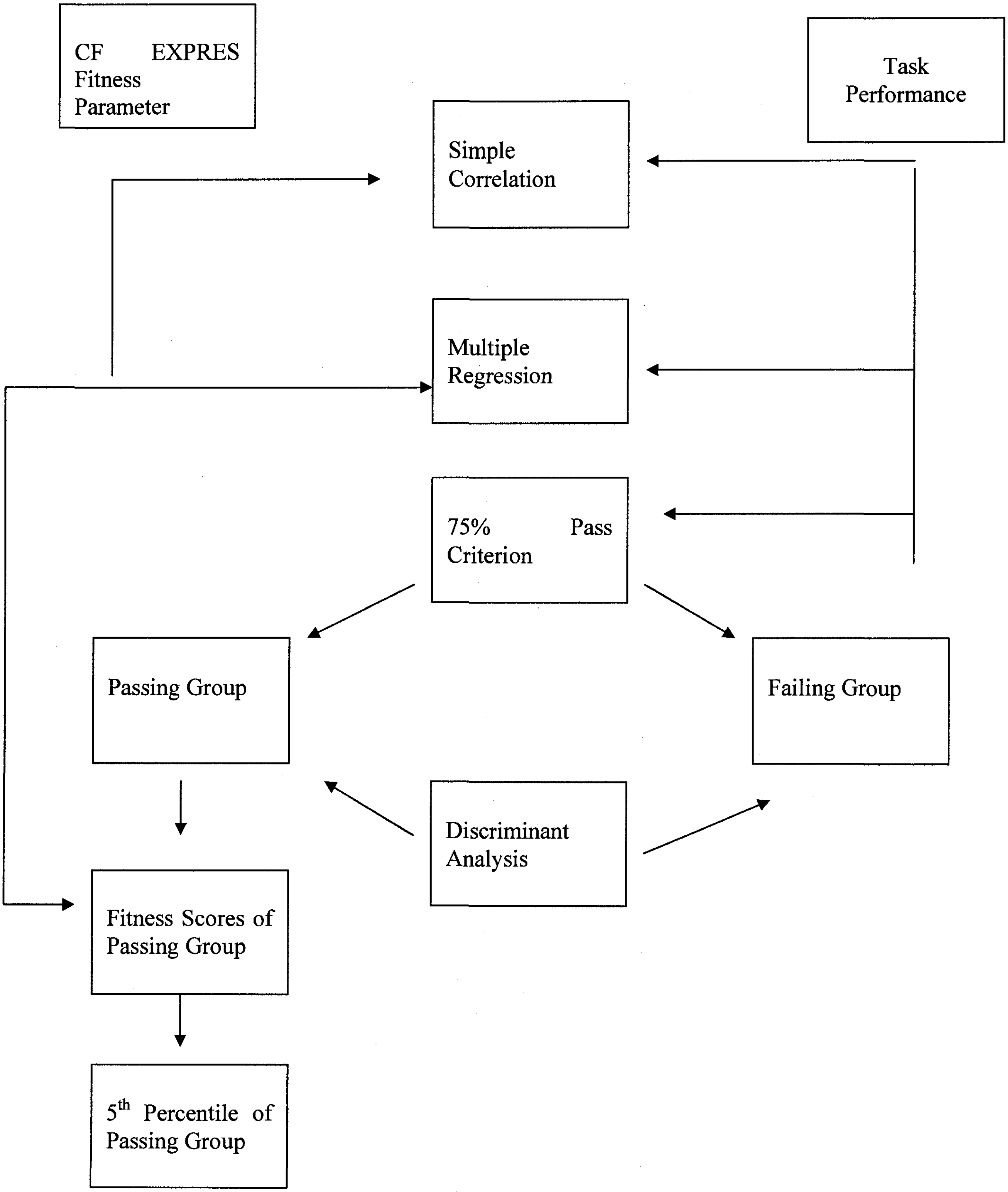
Logistic discriminant analyses were then performed so that passers and failers could be compared for each task and for their fitness scores. A separate discriminant analysis was conducted for females, as there were a disproportionate number of men who passed. Then, a classification table was developed to identify the degree of predictive accuracy and *t* tests were used to identify significant differences between the means for females who passed and failed each component. The test variables that had reliable

Table 2.3. Summary of reliable relationships between EXPRES items and task variables using simple correlation, regression, discriminant analysis, significant differences in means for passing and failing groups.

EXPRES	Entrenchment Dig	Land Evacuation	Low High Crawl	Sea Evacuation	Sandbag Carry
Women < 35 years					
Aerobic Capacity		a d	a b c d		a b d
Handgrip	b d				
Sit-ups		a b c d	b		b
Push-ups			a b c		b
ILM	a b c d	a b c d	a b c d	a b	a b c d
Women ≥ 35 years					
Aerobic Capacity	a	d	a b d		a d
Handgrip	a	b c d		b d	a
Sit-ups			b		a
Push-ups	a		a d		
ILM	a	a b	a		a
Men ≥ 35 years					
Aerobic Capacity	a	a b c d	c		a c d
Handgrip					
Sit-ups		a c	a b c d		c
Push-ups					c
ILM					d

Note: a=variable identified in discriminant analysis; b= reliable difference exists between means of passing and failing groups in predicted direction; c= reliable relationship between fitness variable and task performance indicated by simple correlation; d=variable identified in stepwise multiple regression analysis

Figure 2.1. Flow Diagram for the Development of MPFS



relationships with each task for ither sex were identified, the data for each test was fit to normal distribution, and the passing criterion was then set at the 5th percentile. The resulting MPFS for the CF EXPRES test are outlined in Table 2.4.

Despite finding a relationship between the CF EXPRES test components and the 5CT and selecting these fitness components as "predictors" of successful completion of the 5CT, MPFS 88 also determined that successful performance on the 5CT could not be reliably predicted by performance on the CF EXPRES test. Specifically, the predictive power of the EXPRES test for the 5CT ranged from 5% to 55% while the overall the variance across the tasks averaged 32% (Stevenson 1988; Stevenson 1994). However, because EXPRES scores accounted for approximately one-third of the variances in task performance, experts felt it was reasonable to assess general fitness as a job related performance measure.

Table 2.4. CF MPFS for the EXPRES Test

	MALE		FEMALE	
	< 35 Years	≥ 35 Years	< 35 Years	≥ 35 Years
$V0_2$max	39	35	32	30
Handgrip	75	73	50	48
Push Ups	19	17	15	12
Sit Ups (1 Min)	19	14	9	7

2.3.7 Implement and evaluate the performance standards and testing protocol

The new MPFS for the CF EXPRES test were then examined to determine the impact on CF personnel. It was determined that 92-99% of CF males were capable of meeting the criteria while only 57% of the females were able to meet the criteria. Depending on the task, male scores were 20 to 250% superior to female scores. These results may seem alarming, but similar sex-related differences have also been reported in other physically demanding occupations. For example, research in the Royal Canadian Mounted Police Physical Ability Requirement Evaluation reported that in a sample of 48 young adults who ranged in age from 19 to 31 years (21 males and 27 females) that 91% of the males tested were able to pass the test while only 37% of the females were able to meet the physical requirements (Stanish 1999). Additionally, it has been reported that in general approximately 50% of the females who attempt this test are not physically capable of completing it (1996).

The disparity in performance between sexes is related to both the differences in physiological capacities, but also to the ergonomics of the task. On average, males are taller than females, have longer arm length, have a greater leg length to body length, have less adipose tissue than females (MacKay and Bishop 1984), and have more fat-free mass than females (Wells and Plowman 1983). Additionally, it has been reported that females possess 59% to 84% of a males dynamic strength (Laubach 1976). However, females typically have greater flexibility than males (Blue 1993), regulate their work speed better than males (Redgrove 1979), and develop different work techniques, such as pushing or pulling objects rather than vertically lifting them, which allow them to compensate for some of these physiological differences (Greenhorn and Stevenson 1995). Therefore, simple modifications such as using a shoulder harness for the Land Evacuation vice carrying the stretcher by hand, allowing personnel to self-select a smaller sandbag weight, or providing a lighter weight shovel for the Entrenchment Dig could minimize many of the gender differences. Therefore, in the late 1990s an evaluation of the MPFS

88 physical fitness testing model was conducted to determine if an alternative model was more appropriate or if changes to the MPFS 88 model should be made.

2.3.8 Maintain an on-going review

In 1996, a review of the MPFS 88 commenced. This new research known as MPFS 2000, was conducted to re-evaluate the 5CT and determine if the 5CT were still valid for CF operations, to quantify the physical requirements associated with the performance of these tasks, and to develop a BFOR for CF personnel (Deakin, Pelot et al. 2000). This review was prompted by recommendations from MPFS 88 that encouraged the development of a compensatory sex-neutral model that allow tradeoffs between strengths and weaknesses because of differences in technique for task performance.

2.4 MPFS 2000

2.4.1 Re-evaluate the Five Common tasks and determine validity for current CF operations

In the late 1990s, it was recognized that the role of the CF in international and homeland missions had significantly changed from the Cold War era. Consequently, research commenced to determine if the 5CT were still representative of the most physically demanding tasks in deployment or operational settings. Thus, Deakin and colleagues commenced a media search to assess and determine the types of occupational exposures experienced by CF members during 1986 to 1999 (2000). This search resulted in the identification of four types of missions where CF members were involved. These missions were classified as the following:

1. Domestic Conflict – Example: Oka Conflict;
2. International Conflict – Example: Bosnia, Croatia, Cambodia, Gulf War;
3. Domestic Humanitarian – Example: Manitoba Flood, Eastern Ontario/Quebec Ice Storm; and,
4. International Humanitarian – Example: Somalia peacekeeping, Rwanda peacekeeping.

This media search also identified, that during these missions CF members were regularly required to perform physically demanding tasks that included carrying wounded to safety, evacuating civilians, carrying medicine and food, loading bomb racks, clearing land mines, inspecting vessels in tightly packed containers, and engaging in hand-to-hand combat. It was also noted that some of these missions provided little or no advance preparation or training (Deakin, Pelot et al. 2000). Furthermore, as Table 2.5 illustrates, during this period of time, it was confirmed that many of these operations required CF members to perform "real time/emergency" versions of the 5CT. The Sea Evacuation was the only task not identified in the 2000 analysis. However, the disaster on HMCS Chicoutimi on 5 October 2004 illustrated the need to have the physical fitness to extract personnel from lower decks during a fire while at sea (2004).

Table 2.5. Operational Field Examples of the Five Common Tasks

Operation	Sea Evacuation	Land Evacuation	Low High Crawl	Entrenchment Dig	Sandbag Carry	Lifting*
Oka		X		X	X	X
Manitoba Flood		X			X	X
Ontario/Quebec Ice Storm		X			X	X
International Conflict		X	X	X		X
International Humanitarian				X		X
Gulf War			X			X

(Deakin, Pelot et al. 2000)

The 2000 media search also identified a new key physical component in CF deployments and operations. Specifically, Deakin and colleagues (2000) found that lifting tasks were identified in 100% of the operations examined and therefore a sixth common task was added to the occupational fitness testing battery. The sixth common task was identified as the Jerry Can Lift and was designed to simulate loading jerry cans onto a military vehicle. In this task CF personnel were required to lift as many 20 kg jerry cans to a height of 1.3 as possible within a five minute time limit.

2.4.2 Quantify the physical requirements of the Five Common Tasks

There were significant improvements in technology and changes in military equipment between the completion of MPFS 88 and the commencement of MPFS 2000 and thus in MPFS 2000, it was possible to measure and record the aerobic demands for some of the common tasks. Firstly, the aerobic cost for performing true, field versions of the Low High Crawl and the Entrenchment Dig known as Low Crawl and Shell Scrape Field Tests were conducted. The fitness requirement for these field tests were then directly compared with aerobic cost measurements for the Six Common Tasks protocols for the Land Evacuation, Low High Crawl, Entrenchment Dig, and Sandbag Carry. These field tasks were performed outdoors in military issue combat fatigues, helmets, boots and web gear. The Low Crawl was performed on a 35 m course with three straight sections, two turns, and wire barriers 4m apart at 54 cm in height. The Shell Scrape was performed on earth that was fairly sandy, with some soft clay, and small tree roots and measured 0.6 m by 1.9 m and participants were instructed to dig 0.5 m deep.

The sample size for this evaluation consisted of 25 females (mean age 29 years) and 60 males (mean age 30 years) who ranged in age from 19 to 45 years. However, not all of these personnel completed each task while directly measuring the aerobic demands. The study first evaluated the differences in the aerobic demands for field tests and the laboratory protocols used in the Six Common Tasks. The results as displayed in Table 2.6 demonstrated that for women the field Low Crawl required 0.4% more of the participant's absolute aerobic capacity than the Low High Crawl protocol, but the data also shows that the difference between the field and laboratory protocols for males was much more pronounced. Male personnel required 6% more of the absolute aerobic capacity in the Low Crawl protocol than in the Low High protocol while the Shell Scrape required 4.6% more of their aerobic capacity. These data indicate that although the tests elicit very similar cardiovascular demands that the advances in technology may make it possible to develop occupational tests that more closely reflect the true demands of field activities.

MPFS 2000 also attempted to determine the aerobic demands of the laboratory versions for the tasks. The results of this study are displayed in Table 2.7. They showed that the average aerobic demands for females ranged from 54.3% of their maximal aerobic capacity for the Low High Crawl to 82.5% for the Sandbag Carry. The aerobic demands for males ranged from 57.1% of maximal aerobic capacity on the Low High Crawl to 77.6% on the Sandbag Carry. However, these findings also shown that although the percent of aerobic capacity required to perform the tasks was similar between the genders, the absolute differences were not similar. Specifically, females required an aerobic capacity equivalent to 25.6 ml/kg/min to perform the tasks and a maximum average aerobic capacity of 31.1 ml/kg/min to perform the Sandbag Carry while males, required, on average, 32.8 ml/kg/min to perform the tasks and a maximum aerobic capacity of 36.3 ml/kg/min to perform the Land Evacuation.

The differences in the absolute aerobic demands indicate that females did not require as great a physical capacity as males to successfully complete the task. It was believed that females were compensating for physiological limitations by performing the tasks technically different than males. These data further strengthen the recommendations from MPFS 88, that a sex neutral and compensatory model should be developed. Consequently, MPFS 2000 re-evaluated the EXPRES test and the age and gender norms for MPFS that were developed in MPFS 88.

Table 2.6. Comparison of VO2 Demands on Field Tasks and Common Tasks

	Women				Men			
	Avg Age	# of Trials	Observed VO2max (ml/kg/min)	% of VO2max	Avg Age	# of Trials	Observed VO_2max (ml/kg/min)	% of VO2max
Field Low Crawl	33	2	19.9	54.7	23	6	25.5	51.1
Low High Crawl	32	6	20.3	54.3	30	13	27.0	57.1
Shell Scrape					28	5	30.2	58.6
Entrench Dig	31	8	23.9	66.4	28	16	30.6	64.2

(Deakin, Pelot et al. 2000)

Table 2.7. VO_2 Demands for Some Common Tasks

	Women				Men			
	Avg Age	# of Trials	Observed VO_2 (ml/kg/min)	% of VO2max	Avg Age	# of Trials	Observed VO_2 (ml/kg/min)	% of VO2max
Land Evacuation	25	4	25.1	64.4	29	12	36.3	74.2
Low High Crawl	32	6	20.3	54.3	30	13	27.0	57.1
Entrenchment Dig	31	8	23.9	66.4	28	16	30.6	64.2
Sandbag Carry	28	7	31.1	82.5	32	13	35.7	77.6
Jerry Can	4	28	27.7	68.4	13	30	34.4	70.3
Average		**29**	**25.6**	**67.2**			**32.8**	**68.7**

(Deakin, Pelot et al. 2000)

2.4.3 Develop a BFOR for the CF

The MPFS 2000 standard was developed to provide a single standard for CF personnel regardless of age, sex, rank, or trade. This new standard was created using a compensatory model, which allowed weaker physiological systems could be accommodated by strengths in other systems. For example, an individual with lower muscular endurance may compensate for this "weakness" by having a higher aerobic capacity.

The MPFS 2000 research involved 207 females (mean (±SD) 33 (6), Range: 20 to 48) and 416 men (mean (±SD) 32 (7), Range: 19 to 53) and made several changes to the testing protocol used in MPFS 88. Personnel aged 35 years and older were no longer restricted to 90% of their age predicted HR_{max} when performing the Six Common Tasks as the ACSM adjusted their recommendations for maximal testing. Because of these changes, the CAFT step test was replaced with a maximal test for aerobic capacity, the 20 Meter Shuttle Run (20 MSR). The CAFT step test has a mean square error of 63.3 and reliability of 0.89 (Weller, Tomas et al. 1995) whereas the 20 MSR is considered to have an excellent validity coefficient (r = 0.90), has a standard error of measurement of 9.6%, while test-retest reliability coefficients show that this test is highly reliable (n = 81, r = 0.95)(Léger, Mercier et al. 1988) . Therefore, by using the 20 MSR as the standard test for aerobic capacity, personnel would be provided with more accurate measurements of aerobic capacity.

The MPFS 2000 model included all elements of MPFS 88 (VO2max, handgrip strength, push-ups, and sit-ups,) but also added Vertical Jump and Leg Dynamometer tests to the EXPRES testing protocol. The vertical jump test was added as a measurement of leg power and the leg dynamometer test was added to maximal leg extension strength. The specific methodology for developing MPFS was very complex (Deakin, Pelot et al. 2000), but the basic principle was that all personnel were required to achieve a minimum score on each test. To pass the test, the subjects had to achieve an aggregate score that was greater than all of the minimum scores combined. This process would not allow an individual to achieve a "passing" score by just meeting the minimum on each testing component as they would have to demonstrate individual must have strengths in other testing components. The result of this research was a standardized sex- and age-dependent performance score.

Additionally, because of changes in testing equipment, the passing times for the Six Common Tasks were also re-evaluated to determine what would be "reasonably acceptable" standard. To do this, the mean of each task was determined and then the performance standard was set at two standard deviations below the mean. Unfortunately, the impact analysis of this MPFS 2000 standard indicated that total 28% (N=176) of the entire sample tested personnel tested could not pass the standard. Additionally, 169 of the participants who failed to achieve the minimal standards were females. This research indicated that 82% of the females tested and 2% of the males tested could not meet the standard. As Table 2.8 demonstrates it was determined that a minimum of 43.7% of the females would fail the Sandbag Carry standard while as many as 73.7% could be expected to fail the Jerry Can Lift whereas the failure rates for males was more marginal. As a result of this impact analysis, it was determined that although the MPFS 2000 protocol was more reflective of current CF physical fitness requirements, that the effect of implementing this standard would be too great. Therefore, it was decided in the year 2000 as well as 2006 that the CF would continue using the MPFS 88 model.

Table 2.8. Impact Analysis of Six Common Tasks

Common Task	Gold Standard Passing level	Percentage of Failers	
		Women	Men
Low High Crawl (min:sec)	2:38 or below	58.0	5.8
Land Evacuation (min:sec)	11:23 or below	64.6	2.7
Sea Evacuation (min:sec)	1:07 or below	72.3	0.7
Entrenchment Dig (min:sec)	10:03 or below	52.7	2.9
Sandbag Carry (number)	12 or above	43.7	4.1
Jerry Can Lift (number)	44 or above	73.7	0.2

2.5 MPFS for CF Members 50 Years and Older

2.5.1 <u>Purpose and Methodology</u>

In 2004, an internal assessment of the military population was conducted. This analysis determined that the average age of military members was increasing and that setting the mandatory retirement age to 55 years was resulting in an extensive loss of military expertise. Thus, it was decided that the mandatory retirement age would be extended from age 55 to age 60. However, this policy change had implications on the Universality of Service Principle.

The Universality of Service Principle clearly stated that all CF members were required to have the physical fitness to perform emergency operations, to be deployable, and to perform common defence duties (1985, c.H-6; 2005; 2006). However, when the compulsory retirement age was extended to age 60, research had not yet indicated if CF personnel older than 55 years of age were physically capable of performing operational tasks. Additionally, the only data regarding the physical capabilities of CF personnel 50 to 55 years was collected during the MPFS 88 research study and included only 5 males and 0 females over the age of 50. The discovery of this information resulted in the commencement of a research study that was focused on evaluating the current physical fitness standards for CF members 50 to 55 years of age to determine new fitness standards for members older than 55 years. This research study was titled the MPFS for CF members 50 years and older (Lee, Flanagan et al. 2007). The focus of this study was to do the following:

1. Develop a sub maximal 5CT passing standard for CF members 50 years and older that would accurately predict successful performance on the maximal 5CT passing standard; and,
2. Determine the MPFS for the CF EXPRES for members 50 years and older that would predict successful completion of the sub maximal 5CT passing standard for members 50 to 60 years of age.

2.5.2 Results

The MPFS 50 Years and Older research study consisted of 157 or 3.98% (N=3936) of the CF members aged 50 years or older (October 2006) (Canadian-Forces 10 October 2006). This sample consisted of 130 males (mean (±SD) 54 (3), range: 50 to 59 years) and 27 females (mean (±SD) 53 (3), range: 50 to 58 years), which accounted for 3.7% of the males and 6.1% of the females within this age population. From this total sample, 115 participants aged 50 to 55 years of age attempted to meet the current 35 to 55 year old 5CT standard. Only 41.7% (48 of 115) of these participants successfully met the current 5CT passing standard for CF members 35 to 55 year olds. Specifically, the passing group consisted of 54 males (44.3% of all male participants) (mean (±SD) 53 (3), range: 50 to 59 years) and 0 females. Additionally, a sample of 25 participants, which consisted of 22 males (mean (±SD) 54 (3), range: 50 to 59 years) and 3 females (mean (±SD) 51 (1), range: 50 to 52 years) attempted to meet the "Gold Standard" 5CT passing standard (i.e. without heart rate restrictions, maximal effort). In total, only 55% of participants (n=25) who completed the maximal protocol met the maximal passing criteria for the 5CT. Specifically, 50% of the males (n = 11, mean (±SD) 53 (3), range: 50 to 58 years) and 0% of the females could meet these standards. The results of this research were even more alarming because not only were the failure rates high, but there was also a large number of personnel aged 50 years and older who could not physically complete the tasks. From a sample of 122 males and 25 females only 94.8% of the participants were physically capable of completing all 5CT.

2.5.3 Implications and Recommendations

Results from this research indicated that a small number of CF members, with more females than males, aged 50 years and older, were not physically capable of completing the 5CT. Furthermore, 58.3% of the personnel who physically completed the sub maximal protocol could not meet the current 5CT passing standards for members 35 to 55 years of age and 45% of the personnel who attempted the maximal protocol could not meet the "Gold Standard" fitness standard for the 5CT. Therefore, under the current Defence Administrative Order and Directive (DAOD) 5023-1 (8 May 2005) these members would not be classified as operationally fit and could be released from the CF (Lee, Flanagan et al. 2007). These results indicate that a high proportion of CF members 50 years and older are not be physically capable of meeting the minimum physical fitness requirement. However, it has been proposed by many individuals who do not understand the stressors associated with operational settings, that it may be appropriate to retain CF members who possess a lower level of fitness, but assign them to "back-line" or supporting positions. Therefore, it is important to understand the some of the physiological stressors that are associated with military operations.

2.6 Physical Demands in Operational Settings

2.6.1 Operational Environments

Physical fitness testing is an important component for ensuring that CF members are operationally ready (Shephard 2003). Military operations expose CF members to extreme heat, extreme cold, variations in altitude, energy deficits, sleep deprivation, and prolonged working hours (Nindl 2002; Castellani, Stulz et al. 2003; Hoyt, Opstad et al. 2006). In fact, research has also been shown that simple exposure to these operational environments can increase oxygen consumption by as much as 15% (Bahr, Opstad et al. 1991) and thus increase the rate of fatigue onset. Individually each of these factors has a significant physiological impact; however the combination of these factors with the requirement to perform physically demanding military tasks places an even greater stressor on the military members. Therefore, it is reasonable to conclude that personnel with lower levels of physical fitness will be placed at greater risk of being unsuccessful in responding to an emergency situation because the simple act of being in an operational environment increases their physiological demands.

The working conditions of operational environments can also place great physiological demands on military personnel. Military operations often require personnel to sustain sub-maximal tasks for 13 to 18 hour work-days (2004) or they may also require personnel to perform tasks in awkward postures such as inspecting cargo holds or inspecting insurgent hideaways (2002). These types of activities have a definite energy cost as the adoption of awkward postures has been shown to increase the rate of fatigue onset (2002) while analysis of workplace demands have found that sustaining tasks at 40% of aerobic power is only possible for an eight hour period (normal working day) without suffering fatigue (Astrand 1967). Larger fractions of maximum effort can be sustained for shorter intervals, but this is largely affected by pacing (Bonjer 1968; Hughes and Goldman 1970; Shephard 1990). Therefore, ensuring that CF personnel maintain and improve physical fitness will help minimize the effects of fatigue in operational environments.

The increased rates of fatigue experienced during military operations may also place CF members at an increased risk for developing acute illnesses. Research involving young military men demonstrated that the continuous physical exercise associated with a 5 to 7 day military exercise resulted in caloric deficiencies, sleep deprivation, and also a significant suppression of lymphocyte-related immunity (Boyum, Wiik et al. 1996). Although in this particular study there were not any significant increases in acute illness in the first 4 to 5 weeks after the exercise it was believed that more lengthy operations may increase the incidence of acute bouts of illness. This is particularly important as acute illness can decrease an individual's aerobic capacity by 15 - 20% (Wright, Sidney et al. 1978), and subsequently the military member may be less effective in the operational environment.

2.6.2 Temperature Regulation

Many military operations also expose personnel to extreme temperatures, which have been shown to increase physiological demands. For example, Canadian Forces members that participated in the clean-up for the eastern Ontario / Quebec ice storm (Deakin, Pelot et al. 2000), could be expected to utilize 5 to 10% more energy in this cold environment than if they performed the same activities in a thermo neutral environment (Romet 1986). Additionally, CF Navy members that patrolled the Persian Gulf during the Gulf War (Deakin, Pelot et al. 2000) were routinely exposed to hot, humid environments and thus would have required a 5% increase in oxygen consumption than if they were performing the tasks in a thermo neutral environment (W.D., F.I. et al. 1991). Finally, recent deployments in Kabul, Afghanistan have demonstrated that CF members may be expected to work at altitude or in hot, dry environments. Hot, dry environmental combat situations have been found to equate to moderate to high levels of energy expenditure (Leamon, Nevola et al. 2005) while altitude increases the onset of aerobic fatigue (Shephard 1982).

The effect of military garments has also been shown to affect physical performance. Heat dissipation and heat tolerance can be reduced by 5-10% because of the weight of these garments (Shephard 1974; Duggan 1988; McLellan 1993). Additionally, as the level of military uniforms increase (from combats to partial NBCW to complete NBCW) there is an increase in the energy cost of physical performance (Shephard 1974; McLellan 1993) and a decrease in heat tolerance (Shephard 1974). For example, physical activity performed at 40°C and 50% relative humidity in CF NBCW clothing has been shown to have a two-fold increase in the maximum oxygen consumption as compared to walking in light clothing (Duggan 1988). Therefore, CF members are at greater risk of heat intolerance and require more energy intake to perform tasks in the military uniforms, than would be needed to perform the same tasks in comfortable gym clothing.

2.6.3 Implications

Each of these factors has an independent effect on the ability of a CF member to effectively perform in an operational environment. Therefore, even if the member is not required to perform physically demanding tasks, such as the 5CT, the member would still require greater physical exertion to complete tasks in an operational setting than performing the same tasks in a non-operational setting. Additionally, when increasing age is combined with exposure to operational settings, there is an even greater need to ensure that the CF member has the physical ability to perform the physical demands of the job.

2.7 Effects of Ageing on Physical Performance

Aging does not occur uniformly across the population and individuals of the same chronological age may differ dramatically in response to fitness training (Mazzeo, Cavanagh et al. 1998; Whaley 2006). One person may be considered to be a senior at age 57 because of their health and fitness status while other individuals may be considered to be a "middle aged" adult. These age related changes include declines in maximal heart rate, maximal cardiac output, aerobic capacity, vital capacity, muscular strength, flexibility, bone mass, fat-free mass, glucose tolerance, and reaction time and include increases in resting and exercise blood pressures, residual volume, and percent body fat (Mazzeo, Cavanagh et al. 1998; Whaley 2006). However, research has also shown that health and lifestyle choices can minimize many of these changes.

2.7.1 Aerobic Capacity

Maximal aerobic capacity is maximum amount of oxygen that can be delivered to and consumed by the body tissues per unit of time. The term VO2max is the term used to measure the functional capacity of the oxygen transport system. This measurement is typically expressed as the maximum volume of oxygen consumer per minute ($l \bullet min^{-1}$) or in millilitres per kilogram of body weight per minute (ml/kg/min) (2001). From a practical standpoint, a high VO2max in ml/kg/min will allow an individual to sustain high levels of exercise for an extended period of time relative to their body weight while a high VO2max in $l \bullet min^{-1}$ may or may not correspond to increased performance. Therefore, to optimize performance, focus should be placed on maximizing VO2max in relation in the member's body weight.

The simple act of ageing has also been related to decreases in aerobic capacity. The ACSM indicates that a decrease of 5 to 15% of VO2max can be expected for every decade after age 25 (Mazzeo, Cavanagh et al. 1998). However, research also indicates that many of these age related declines can be diminished by maintaining high levels of exercise training (Mazzeo, Cavanagh et al. 1998). In fact, older adults, just like young adults, can experience a 10 to 30% increase in their VO2max by training at higher intensities(Mazzeo, Cavanagh et al. 1998).

2.7.2 Muscular Capacity

Sarcopenia is the loss of muscle mass and strength and can be caused by ageing (Roubenoff 2000). Humans experience a decrease in total muscle mass that is equivalent to 50% of their peak strength between age 20 and 90 years and much of this decrease occurs between age 50 and 70 years (Mazzeo, Cavanagh et al. 1998). Specifically, strength declines at a rate equivalent to 15% of peak strength during the 6th and 7th decade and then about 30% thereafter (Mazzeo, Cavanagh et al. 1998). Sarcopenia is caused by many factors that include changes in the central nervous system, in muscle contractility, muscle cell biology, and hormonal factors, but is well documented that that sarcopenia is worsened by disuse and low levels of physical activity (Roubenoff 2000). Therefore, it is important that physical activity and fitness training are maintained throughout the lifetime to minimize the effects of sarcopenia with ageing .

In regards to the CF population, it is particularly important that ageing CF members place great emphasis on trying to minimize the effects of age related strength declines by regularly participating in physical activity that incorporates strength training. This emphasis is particularly important for ageing females as females are at a higher risk of experiencing the effects of sarcoponia. Females typically have 30% less absolute upper body strength and 5% less lower body strength than men and therefore decreases in absolute strength affect females more than males. Additionally, research by Jette and Branch indicated that approximately 40% of the female population aged 55 to 64 years of age cannot lift 4.5 kg (Jette and Branch 1981). Therefore, it is extremely important that extensive time is devoted to maintaining muscular strength, particularly for ageing females, as the physical demands of common military tasks such as the Sandbag Carry (20 kg) or Land Evacuation (80 kg soldier) are much more physically demanding

2.7.3 Body Composition

Body composition also has an impact on physical performance. In industrialized countries, the increasing number of obese individuals is a major problem (Whaley 2006). Unfortunately, the CF is not exempt from these societal norms. Obesity is often measured by Body Mass Index (BMI) as it provides a measurement of weight in proportion to height (weight in kilograms divided by the square of height in meters). BMI cannot discriminate between individuals who have a high body mass because of a high proportion of lean body mass (muscle, bone, etc), but BMI has been proven to be an effective method for identifying personnel with increased health risk (Janssen, Katzmarzyk et al. 2002). The National Institutes of Health published a study that involved 14924 subjects aged 17 years and older, which found that health risk increases significantly when BMI is greater than a Normal/Healthy Range of 24.9 kg/m^2(Janssen, Katzmarzyk et al. 2002). These categories are outlined in Table 2.9. Additionally, research with the US Air National Guard demonstrated that a higher BMI is associated with increased incidence of line of duty injuries (2002).

Table 2.9. NIH Body Weight Classifications According to BMI.

Underweight	Normal Weight	Overweight	Obese I	Obese II	Obese III
<18.5	18.5-24.9	25.0-29.9	30.0-34.9	35.0-39.9	≥40

In the CF, the rate of personnel who are classified as Overweight or Obese has remained relatively steady since 1990, but it is important to note that current trends of obesity are higher in the CF than in the general Canadian population. Table 2.10 demonstrates the percent of CF personnel who have a BMI greater than 25 $kg•m^2$, which are classified as "Overweight." Currently, 74% of males and 41% females in the CF are classified as Overweight or Obese I category (2005) . In the general Canadian population, 66.5% of males and 38.4% of females fall within these categories (2005). It is possible that some CF members classified as overweight have a high proportion of muscle/lean body mass, but it is unlikely that all of these personnel have a higher normal lean body mass.

Table 2.10. Percent of CF members classified as having a BMI higher than the Normal/Health Category (>25 kg/m^2)

	Year	N	Males	Females
Jetté and Sidney (Jette and Sidney 1990)	1990	19, 185	76%	37%
2000 CF Self-Reported Survey (2002)	2000	27, 615	70%	43%
2004 CF Self-Report Survey (2005)	2004	3, 019	74%	41%

High body mass index has also been related to poorer physical performance. A 1990 study with 17098 CF men and 2097 CF women found that higher BMI zones were typically associated with lower fitness and performance scores than personnel in a lower BMI (Jette and Sidney 1990). In comparison, Popper and colleagues, stated that there is no consistent relationship between body fat content and physical performance in U.S. military members, but that there was a direct relationship between physical performance as measured by tests of load carrying ability and lifting abilities to and the amount of lean body mass (Popper 1999). Increasing BMI has been found to have a negative effect on physical performance and quality of life in elderly individuals (Bohannon, Brennan et al. 2005). Therefore, in the CF population it seems likely that older personnel who have a higher BMI would be at greatest risk for suffering decrements in performance or sustaining line of duty injuries. These studies demonstrate that although the effect of BMI has not always been found to have a deleterious effect on performance, increasing BMI can affect quality of life and that increasing BMI is associated with increased health risk and increased incidence of line of duty injuries.

2.7.4 Lifestyle and Physical Activity Changes

There is significant evidence that indicates that regular exercise is an effective intervention / modality for reducing and preventing functional declines associated with ageing and that regular physical activity is an effective method for maintaining and improving a healthy body composition (Mazzeo, Cavanagh et al. 1998). Data also shows that 40% of CF members (41% of males and 37% of females) are physically active, 27% are moderately active, and 33% are inactive (2005). These numbers are better than the Canadian population norms, where 46.2% of Canadians reported being physically inactive and only 51.6% as being physically active (2005), but there is reason for concern. In the CF there was a decrease in reported physical activity levels during the period of 2000 to 2004 with the oldest group of CF personnel (45 to 54 years) reporting the least amount of physically active personnel (30%)(2005).

Unfortunately, work place physical activity has not been found to contribute to overall physical activity levels. The 2004 Canadian Forces Regular Force Health and

Lifestyle Information Survey reported that very high levels of physical accounted for only 5% of the sample population and that high levels and moderate levels of physical have decreased from 18% in 2000 to 14% in 2004 and from 42% to 41% respectively. However, there was a 5% increase in low levels of work place physical activity (from 36% to 40%, (2005).

2.8 Conclusion

Research conducted to date concludes that the 5CT are still relevant for successful occupational performance in the CF, that the performance of these tasks is physically demanding, and that these physical demands may increase when performing a task in a true operational setting. Research also indicates that there are many declines in functional capacities that are associated with ageing and that females typically have a lower functional capacity than males. However, CF data indicates that a large percent of CF personnel have a BMI that is classified as overweight, which is often associated with a higher health risk and lower physical performance. Additionally, it has been shown that older personnel have the lowest levels of physical activity, and that CF personnel are not sustaining enough physical activity in the workplace to gain any health benefits or fitness improvements. Therefore, it is believed that CF members with a higher BMI, those who are older, and female members in the CF are at greatest risk for not possessing the physical capacities to meet the physical requirements of the 5CT.

CHAPTER 3

METHODOLOGY

3.1 Subjects

3.1.1 Recruitment and Selection

The data analysis for this study was conducted from a secondary analysis of data collected in the MPFS 50 Years and Older Research Project. All subjects in the MPFS 50 Years and Older Research study were contacted directly via email to request their participation. The initial invitational email was provided in both official languages, but recruitment was limited to CF personnel who could read and/or verbally understanding English. The CF also circulated information through their communication networks, which indicated that interested personnel should identify themselves to their chain of command and that authorization to participate in this research should be provided to all interested individuals. Testing was completed at three different CF bases during the 2006 calendar year. The schedule of specific testing dates is outline in Table 3.1.

The research design and protocols were approved by ethica Clinical Research Incorporated's Research Ethics Board who is fully accredited from the Association for the Accreditation of Human Research Protection Programs (AAHRPP). Participation was completely voluntary and participants were not subject to career implications, to administrative action, or to punishment under the Code of Service Discipline for choosing not to take part in, for discontinuing participation, or as a result of their results in the study. Participants were free to stop at any time during the experimental session and remove themselves from the entire study without prejudice. Participation in this study occurred as an extension of normal CF work and therefore all participants were considered to be "on duty" (CBI-205.48 2006). Liability for these members remained within the Regulations, Orders, and Directives of the CF and therefore all participants were required to have chain of command permission to participate in the study.

Table 3.1. Location and dates of testing locations.

Base	Targeted area of CF population	Protocols	Dates
CFB Borden	Central Canada	Sub maximal	30 January – 24 February 2006
CFB Kingston	Central + Atlantic Areas	Sub maximal	12 – 15 June 2006
CFB Petawawa	Central + West Coast	Sub maximal, Maximal, Laboratory	22 November – 7 December 2006

All participants were provided with rations, quarters, temporary duty allowance (TD) in the amount of $15.00/half day of testing (as per CBI 205.48) (CBI-205.48 2006), mileage (as per Treasury Board guidelines), and/or shuttle service to and from the testing site. Additionally, as per the guidelines of DAOD 5061-1 (D.A.O.D.-5061-0 2006; Forces 2006), all CF members were provided with a Protocol Summary prior to testing and were required to complete an Informed Consent form prior to participating in research.

3.1.2 Medical Clearance

The CF does not typically require pre-testing physicals for sub maximal or maximal physical fitness testing (Canadian-Forces-Health-Services-Policy-and-Guidance 2006). However, in this research study, a new medical clearance was required for each participant. Personnel with a Temporary Employment Limitation or Restriction on Duty were ineligible to participate in the research. Only CF members with a "medically fit" classification were eligible to participate.

All potential participants were required to complete a Health Appraisal Questionnaire and present this form to their physician with a Summary of Testing Requirements for Physicians and Medical Clearance Form so that their "medically fit" status could be documented. Participants were requested to have their physician identify if the CF pre-testing HR (<100 beats per minute (bpm)) and BP limits (140/90) (Personnel-Support-Programs 2005) were appropriate for the individual or alternatively provide individualized limits. Physicians were also asked to identify any tasks that may be contraindicated for the member. Participants who volunteered for the Maximal 5CT protocol were also requested to have their physician determine their ACSM Risk Stratification (Whaley 2006) and to authorize their participation in the maximal 5CT.

3.2 Protocol Design

3.2.1 Safety

All tests were conducted under standard exercise conditions for human exercise experiments as laid out in the CF's Defence Administrative Orders and Directives (DAOD) 5061-0, 5061-1, the Compensation, Benefits and Incentives 205.48, and in recommendations by the American College of Sports Medicine (2006; D.A.O.D.-5061-0 2006; D.A.O.D.-5061-1 2006; Whaley 2006). Personnel who were Certified Fitness Consultants, Professional Fitness and Lifestyle Consultants or Certified Exercise Physiologists by the Canadian Society of Exercise Physiology conducted all testing. All staff were First Aid and CPR qualified and were authorized to stop testing should they feel that any individual was at risk. Additionally, the maximal 5CT testing was supervised by personnel who held Advanced Cardiac Life Support (ACLS) qualifications.

3.2.2 Overview

The MPFS 50 years and older research study consisted of two parts: a sub-maximal 5CT protocol and a sub-study where a maximal 5CT protocol was used. All participants in the sub maximal study were requested to complete five testing sessions where they attempted the sub maximal 5CT testing protocols and one testing session for the EXPRES test. All anthropometric measurements were taken during the EXPRES session. Participants were indiscriminately assigned to groups and the order of task testing (5CT and EXPRES testing) was randomized between groups. The order of protocol testing (sub maximal and maximal) was randomized as was the order of tasks administration within each protocol. This research design was used to try and minimize any learning effect from performing the 5CT either sub-maximally or maximally. Only one task was performed per session (i.e. one task in the morning, one task in the afternoon.) Additionally, participants that were cleared for participation in the sub-study using maximal protocols for the 5CT were requested to complete an additional six sessions to complete maximal 5CT testing and laboratory testing. A rest period of at least two hours was provided between tasks testing.

Each testing session began and ended with HR and blood pressure (BP) readings. The HR and BP provided by the participant's physician and identified in the participant's Medical Clearance were used as pre and post-testing maximum limits. If a participant demonstrated a value that exceeded their individualized Medical Clearance limits, they were asked to rest in a supine position for a minimum of ten (10) minutes and then have a second pre-screening medical. If, after prolonged rest, the subject's HR and BP values still exceeded the guidelines or the readings did not decrease, then the participant was excluded from testing for the remainder of the day and they were referred to a CF physician for consultation in regards to their ability to continue with testing on subsequent days.

Each session was initiated by the evaluation staff who read the task protocol, explained the scoring system and provided a demonstration of the task. When applicable, the participants were provided with the opportunity to practice the task so that the evaluator could provide feedback regarding task performance and safety. A formal question period was provided after the explanation and demonstration for each task.

All participants were led in a task specific, standardized warm-up that was conducted approximately 10 to 15 minutes prior to the commencement of their test. Then, when the participant felt adequately prepared, the evaluator individually repeated the task description / explanation and again asked for questions. Once the instructions and warming phase were completed, the participant attempted the test. Finally, upon completion of the task, participants were required to complete a monitored cool-down and complete their post-testing HR and BP reading.

3.2.3 CF EXPRES test methodology

In this research, the EXPRES test consisted of Anthropometric measurements, a Canadian Aerobic Fitness Test (CAFT) step test, handgrip strength, maximum number of continuous push ups, and maximum number of sit-ups in one minute (Personnel-Support-Programs 2005). The testing components were administered in the following order with the following protocols:

a. Anthropometric measurements were taken with a plastic measuring tape and consisted of height, weight, chest circumference, Canadian Standardized Test of Fitness waist circumference protocol, World Health Organization waist circumference protocol, Hip circumference, and Right Thigh circumference. Weight was measured to the nearest 0.1 kg while all other measurements were taken to the nearest 0.5 cm.

b. Handgrip strength was measured with a Smedley handgrip dynamometer. Two trials per hand were taken with the maximum score for each hand added together to provide the handgrip score. Trials alternated from right hand to left hand with no rest periods between each trial. Measurements were taken to the nearest 0.5 kg.

c. The push-up protocol began with the subject in the full horizontal position with the stomach flat on the floor, arms shoulder width apart, and toes as a fulcrum point. Participants were instructed to fully extend their arms and then lower their body until the tops of their arms are parallel to the ground while maintaining a horizontal body position. The initial, approved position of the hands, feet, and body form had to be maintained for the push-ups to be counted. The test was discontinued as soon as the subject was seen to strain forcibly to complete a push-up or they paused / stopped. The Up position was counted as one.

d. The sit-up protocol was performed on a standard 2.5 cm thick, high density gym mat. Participants began by lying on their back, with knees bent to approximately 90 degrees, feet placed approximately 30 cm apart, and feet held down by a partner. The hands were placed beside the head, and had to remain in this position at ALL times. Personnel curled up until their elbows touched the knee. This had to be done without lifting the lower back or hips off the ground. When returning/curling back to the mat, the shoulder blades had to touch the mat. Participants were required to perform as many sit-ups as possible in a period of one-minute.

3.2.4 Five Common Tasks methodology

The 5CT fitness test consists of the Land Evacuation, Sea Evacuation, Low High Crawl, Entrenchment Dig, and Sandbag Carry. A brief explanation of each task is outlined as the following:

a. Land Evacuation. The Land Evacuation is designed to simulate the emergency rescue of a seriously injured 80 kg person over 1 km of hostile territory. In this task participants must lift 40 kg and move a stretcher that has been modified to allow one-person testing a distance of 750 m on a smooth indoor surface (arena). The stretcher was modified to allow one-person testing by adding wheels to one end of the stretcher and also by allowing adjustments to the stretcher to accommodate the participant's height and arm length.

Participants could walk, run, or any combination of walking and running. Additionally, they could stop and rest at any time, but the stretcher had to be lowered to the ground and not dropped. The frequency and duration of the rest periods were left to the discretion of the participant, but they were encouraged to complete the task as fast as possible.

The subject started in front of the stretcher. At the start signal, they gripped the stretcher handles, arms at the side and palms facing medially and then began carrying the stretcher through the circuit. The stretcher apparatus could not be used as a rickshaw or wheelbarrow and the arms had to remain relatively extended and straight. Subjects were required to wear a weight belt to provide waist and back support and were encouraged to keep the back as straight as possible, to maintain a pelvic tilt, and to use their legs to lift the mass. Gloves, chalk, and tape were available.

b. Sea Evacuation. The Sea Evacuation is a simulation of a casualty evacuation from the lower deck of a ship during a fire. The primary criterion of this task is the safe extraction of a casualty and therefore safety, not speed, is the primary concern. In this task participants wore firefighter clothing while performing the following:

The Sea Evacuation commenced with a Stokes Stretcher carry with 80 kg of weight affixed. The participant carried the stretcher a distance of 25 m and was assisted by a lab assistant who carried the back end of the stretcher. The Stokes Stretcher was then placed on cement blocks and the participant moved immediately to the rear of the Shipboard Simulator.

The Shipboard simulator is a broad based superstructure that is a simulation of a flight of stairs between two decks on a ship. The simulator stairs are 3 m in height and are set at a 60 degree angle. The Shipboard simulator was been designed so that one person can move an 80kg person on a Stoker Stretcher up and down a set of stairs through the assistance of a moveable apparatus. The moveable apparatus was formed by attaching the rear half of a Stoker stretcher to a freely hanging crossbar and allowing the wheels of the stoker stretcher to slide in tracks that are bolted to and run along side the stairs. Free weights were affixed so that the total weigh of the moveable apparatus plus weight plates (25 kg) is 80 kg. A pulley system and rope acted as a safety device. Pulleys were attached to the crossbar of the moveable apparatus and to the top of the tracks. The rope was fed through this pulley system and is controlled from the ground by one of the evaluators.

The subject climbed the Shipboard Simulator stairs while carrying / pushing the moveable apparatus as if it were the Stoker stretcher. When the front wheels hit the stoppers at the top of the tracks the subject was provided with an automatic and mandatory 5 second rest period. This pause was provided for safety reasons. However, if additional rest was required, participants were encouraged to remain at the top of the stairs and rest. When the participant was prepared to continue, they signaled "OK" to the belayer and then descended. Participants then moved down the stairs until the back wheels of the moveable apparatus hit the stoppers at the bottom of the Shipboard Simulator. Then, they stepped to the rear of the Stoker Stretcher, picked it up and carried it, with the assistance of the evaluator (at the front end) to the Finish line (same point as Start line).

Each participant was given the opportunity to try the "on-deck" lift and to experiment with carrying techniques outlined in the Evaluator's Manual of the MPFS 50 Years and Older Research Study (Lee, Flanagan et al. 2007). Participants first practiced without any weights in the stretcher. Then, once a preferred and comfortable technique was chosen, they could practice 3 or 4 steps up and back down with a full load. The total time to complete the tasks was recorded in seconds.

c. Low High Crawl. The Low High Crawl simulated a situation where personnel were pinned down by enemy fire and had to employ the low and high crawl techniques to remove themselves from a dangerous area in the fastest time possible. In this task personnel crawled through a 75 m course that consisted of a 30 m low (leopard) crawl, a 90 degree turn, and then a 45 m high (kitten) crawl on the hands and knees. The crawl was performeded in full combat clothing including helmet and fatigues while carrying a rubber C7 rifle over a firm, yet soft, runway. Participants were required to wear knee and elbow pads.

The Low Crawl course contained 16 barriers that were 45 cm in height and 180 cm wide. The barriers were placed at 2 m intervals along the low crawl course. The low crawl was done by crawling with the stomach on the ground and using the elbows and the inside of the knees to propel oneself along the chute. The heels, head, body and elbows were kept down and participants were encouraged to roll the body a little as each knee is bent. Finally, the C7 replica weapon was held with one hand on the pistol grip or small of the butt and the other hand at the forestock with the ejection port facing up.

The high crawl is useful behind cover about 60 cm high. It is simply crawling on the hands and knees. The backside and head were kept down but eyes were forward. The weapon was held in one hand during the crawl and could not be slung over the back. The two crawls are technically different and therefore participants were provided with a "practice" course where the evaluator identified points of technique for each of the crawling styles prior to commencing the testing course. The total time to complete the course was recorded in seconds.

d. Entrenchment Dig. This task is designed to simulate the digging of a "foxhole," which would provide military personnel with protection against incoming enemy fire. In this task participants dug using a (spade) shovel and their hands to empty a wooden 1.8 m x 0.6 m x 0.45 m box containing finely crushed and slightly moistened rock. The rocks were emptied to an identical, empty box until there was less than one shovel full left in the box. All participants wore a weight belt to provide waist and back support. The total time to empty the box was recorded in seconds.

e. Sandbag Carry. This task simulates an emergency flood control situation and is designed to simulate the ability to provide self- protection or protection of others from natural elements. In this task, subjects had 10 minutes to move as many sandbags as possible a distance of 50 m. The bags weighed 20 kg and could only be moved one sandbag at a time.

Participants could walk, run, or use any combination of walking and running while carrying bags or when returning to the starting position. When the command "GO" was provided, participants reached down, picked up a sand bag, moved a distance of 50 m, placed the sandbag on the ground in an orderly fashion and returned to the start point (50 m away) to retrieve another sandbag.

Participants were encouraged to keep the weight as close to their body and to use one of the approved carrying methods that were outlined in the MPFS 50 Years and Older Research Study Evaluator's manual (Lee, Flanagan et al. 2007). All personnel wore a weight belt to provide waist and bask support and were encouraged to use their legs to lift the bags from the floor, to keep their back straight, and to maintain a pelvic tilt. The total number of bags moved was awarded one point plus each additional 10 m moved from a sandbag pick up was awarded an additional 0.1 points.

3.2.5 Sub maximal Five Common Tasks Protocol

The 5CT protocol was used in this sample, but all participantsI were limited to 90% of their age-predicated HR_{max}. Participants were provided with a POLAR watch and a POLAR HR Team System strap that recorded and stored all HR data collected during 5CT Testing. The watches were preset to a limit that was equivalent to 90% of the individual's age-predicated HR_{max} by using the following equation:

$$90\%\ HR_{max} = 0.9\ ((220\text{-}age) - HR_{rest}) + HR_{rest} \qquad (1)$$

where a standard 70 beats•min^{-1} was used as HR_{rest}. When the participant exceeded this preset limit, an audible alarm sounded and the participant was required to stop the task. When the alarm ceased, the participant could continue with the task. Time continued to run during this resting period. This protocol was used because the current study replicated the methods used to set MPFS standards for CF members 17 to 55 years in the MPFS 88 research study.

Prior to any measurements of body composition (i.e., BMI or WC) or participation in any physical fitness tests, all participants were asked to complete The Healthy Physical Activity Participation Questionnaire from the Canadian Physical Activity, Fitness, and Lifestyle Approach(Gledhill, Wheeler et al. 2003). This questionnaire was used to evaluate three aspects of physical activity participation: frequency, intensity, and perceived fitness. The participants were asked the following questions and asked to select only one answer:

- Frequency: Over a typical seven day period (one-week), how many times do you engage in physical activity that is sufficiently prolonged and intense to cause sweating and rapid heart beat?
    - Rarely or Never
    - Normally Once or Twice
    - At least Three Times
- Intensity: When you engage in physical activity, what impression do you have of your effort?
    - Light Effort
    - Moderate Effort
    - Intense Effort
- Perceived Fitness: In a general fashion, what would you say is current physical fitness?
    - Very Poor or Poor
    - Average
    - Good or Very Good

3.3 Delimitations and Limitations for the Current Study

The sample selection for this study was restricted to CF members that were classified as "medically fit" and to those that were able to receive a signed medical clearance form. The participants in this study were volunteers and consequently, it is highly possible that they were more accustomed to physical activity and that they had a higher level of fitness than personnel who chose not to volunteer. Because subject recruitment was limited to CF members that were able to speak and understand English, the transferability of this research is limited to personnel who are angolophone or speak English as their second language. Finally, as the testing protocols for the 5CT and Laboratory testing were unfamiliar to the participants, the familiarization of the participant with the task protocols were limited to the demonstration, explanation, and observation of the protocol.

There were also limitations in the research study design as the protocols for the current study replicated those used in the MPFS 88 study. Specifically, MPFS 88 identified that the loads selected or methods used may not have been optimal. For example, the load on the land stretcher was fixed at slightly heavier than the average man's weight of 80 kg while the use of shoulder straps could considerably change the distribution of the load. Additionally, the sandbag weight was arbitrarily selected (Stevenson 1988). Additionally, because the current research was limited to testing the MPFS 88 components (aerobic, handgrip, push-ups, sit-ups) of the EXPRES test it cannot be determined if other components of fitness (i.e. flexibility, back endurance, etc) are required to successfully complete the 5CT for CF members 50 years and older. It is possible that other tests of fitness (i.e. back extensor test or sit and reach test) may have been better predictors of successful 5CT performance for members 50 years and older than the current components of the CF EXPRES test.

Finally, the research is limited to the reliability and validity of the fitness component tests used. Specifically, it is known that the 20MSR has an excellent validity coefficient (r = 0.90), has a standard error of measurement of 9.6%, while test-retest reliability coefficients show that this test is highly reliable (n = 81, r = 0.95) (Léger, Mercier et al. 1988), but because the current study is replicating the exact methods used in MPFS 88, the CAFT step test was used. The CAFT step test has a mean square error of 63.3 and reliability of 0.89 (Weller, Tomas et al. 1995) and thus is a less accurate measurement of aerobic capacity than the 20 MSR.

3.4 Statistical Analyses

All participants in the MPFS 50 Years and Older Research Study were assigned anonymous codes and data was entered and stored through the assignment of these codes. The data was then entered into SPSS 15.0 by two independent evaluators and was cross-referenced to ensure accuracy. The data analyzed in the current study remained anonymous by use of the coded identifiers assigned in the MPFS 50 Years and Older Research Study.

3.4.1 Hypothesis #1

Hypothesis #1, that "increasing BMI is associated with increasingly poorer performance on the Five Common Tasks and CF EXPRES test was tested by performing the following steps:

a. A two-tailed, Pearson product-moment correlation with a significance level of 0.05 was used to determine if increasing BMI is associated with poorer performance on each of the Five Common Tasks as well as on each component of the CF EXPRES test.
b. Analysis was done for the entire group as well as separate analysis for the sexes. Missing values were excluded case by case.
c. The NIH BMI health risk classifications were the used to identify BMI groups. A one-way analysis of variance (ANOVA) was conducted to determine if poorer performance on a task / tests is associated with NIH BMI health risk classifications. A significance level of 0.05 was used and any groups with significant differences were analysed via Tukey's post hoc tests.

3.4.2 Hypothesis #2

Hypothesis #2, that "Males with a WC greater than or equal to 102 cm and females with a WC greater than or equal to 88 cm will demonstrate poorer performance on the Five Common Tasks fitness test and CF EXPRES test than males who have a WC less than 102 cm and females who have a WC less than 88cm" was tested by performing the following steps:

a. The participants were separated into genders. Then, a two-tailed, Pearson product-moment correlation was used with a significance level of 0.05 to determine if increasing WC is associated with poorer performance on each of the Five Common Tasks as well as on each component of the CF EXPRES test for males and females.

b. The sexes were then classified by the NIH WC health risk classifications as either higher health risk group (males with WC ≥ 102 cm and females with WC ≥ 88 cm) or lower health risk group (males with WC < 102 cm and females with WC < 88 cm).

c. A two-tailed independent t-test was conducted for each sex. A significance level of 0.05 was used to demonstrate if there were significant differences between the higher and lower groups. Missing values were excluded case by case.

3.4.3 Hypothesis #3

Hypothesis #3, that "a BMI that falls within the NIH BMI classification for overweight or obese combined with the higher WC classification will be associated with the poorest performance in both the Five Common Tasks and the CF EXPRES test" was tested in the following manner:

a. All participants were separated into sexes and then classified into one of the following anthropometric subgroups:

- Healthy BMI – Low WC
- Healthy BMI – High WC

- Overweight BMI – Low WC
- Overweight BMI – High WC
- Obese BMI – Low WC
- Obese BMI – High WC

b. A one-way analysis of variance (ANOVA) was then conducted with a significance of 0.05 used to demonstrate significant differences within and between the categories.

3.4.4 Hypothesis #4

Hypothesis #4, "Lower aerobic capacity, muscular strength, and muscular endurance as measured in the CF EXPRES test will be associated with poorer performance in the Five Common Tasks," was tested by performing the following:

a. A two-tailed, Pearson product-moment correlation was used with a significance level of 0.05 to compare aerobic capacity, handgrip strength, maximum number of toe-fulcrum push-ups, and full sit-ups with performance on each of the Five Common Tasks.

b. Analysis was conducted for the entire group and was subdivided into genders. Missing values were excluded case by case.

CHAPTER 4

RESULTS

4.1 Descriptive Statistics

4.1.1 Physical Activity Participation

A total of 120 males and 25 females completed The Healthy Physical Activity Participation Questionnaire from the Canadian Physical Activity, Fitness, and Lifestyle Approach. This questionnaire was used to e participation: frequency, intensity, and perceived fitness. The participants were asked the following three questions to evaluate their physical activity:

- Frequency: Over a typical seven day period (one-week), how many times do you engage in physical activity that is sufficiently prolonged and intense to cause sweating and rapid heart beat?
  - Rarely or Never
  - Normally Once or Twice
  - At least Three Times
- Intensity: When you engage in physical activity, what impression do you have of your effort?
  - Light Effort
  - Moderate Effort
  - Intense Effort

- Perceived Fitness: In a general fashion, what would you say is current physical fitness?
  - Very Poor or Poor
  - Average
  - Good or Very Good

As Table 4.1 demonstrates, 80% of the males and 76% of females reported engaging in physical activity at least three times per week while a total of 118 males and all of the females reported exerting effort that was greater than or equal to a moderate effort. Additionally, in this sample of CF members 50 to 59 years of age 78.3% of the males and 72.0% of the females felt that their physical fitness was above average.

Table 4.1 Frequency, Intensity, and Perceived Effort of Physical Activity

		Males		Females	
		n	%	n	%
Frequency	Rarely or Never	1	0.8%	2	8.0%
	Normally Once or Twice	23	19.2%	4	16.0%
	At least Three Times	96	80.0%	19	76.0%
Intensity	Light Effort	2	1.7%	0	0.0%
	Moderate Effort	58	48.3%	14	56.0%
	Intense Effort	60	50.0%	11	44.0%
Perceived "Current" Physical Fitness Status	Very Poor or Poor	2	1.7%	2	8.0%
	Average	24	20.0%	5	20.0%
	Good or Very Good	94	78.3%	18	72.0%

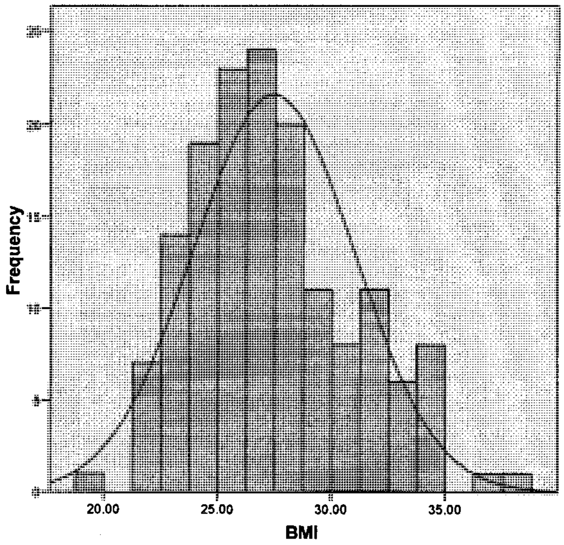
4.1.2 BMI Whole Group

A total of 154 CF members 50 to 59 years were evaluated for their height and weight. The mean BMI for the whole group was 27.4 kg/m^2 (SD ± 3.6), which is classified as Overweight by the NIH. The BMI for the entire group ranged from 19.8 kg/m^2 to 38.6 kg/m^2 and correspondingly was classified as Normal/Healthy Weight to Obese II. A histogram demonstrating the distribution of BMI for the entire group is demonstrated in Figure 4.1.

Table 4.2 BMI Descriptive Statistics

	Whole Group	*Males*	*Females*
n	154	127	27
Mean	27.4 kg/ m^2 (± 3.6)	27.7 kg/ m^2 (±3.4)	25.8 kg/ m^2 (± 3.6)
Min	19.8 kg/ m^2	21.5 kg/ m^2	19.8 kg/ m^2
Max	38.6 kg/ m^2	38.6 kg/ m^2	33.9 kg/ m^2

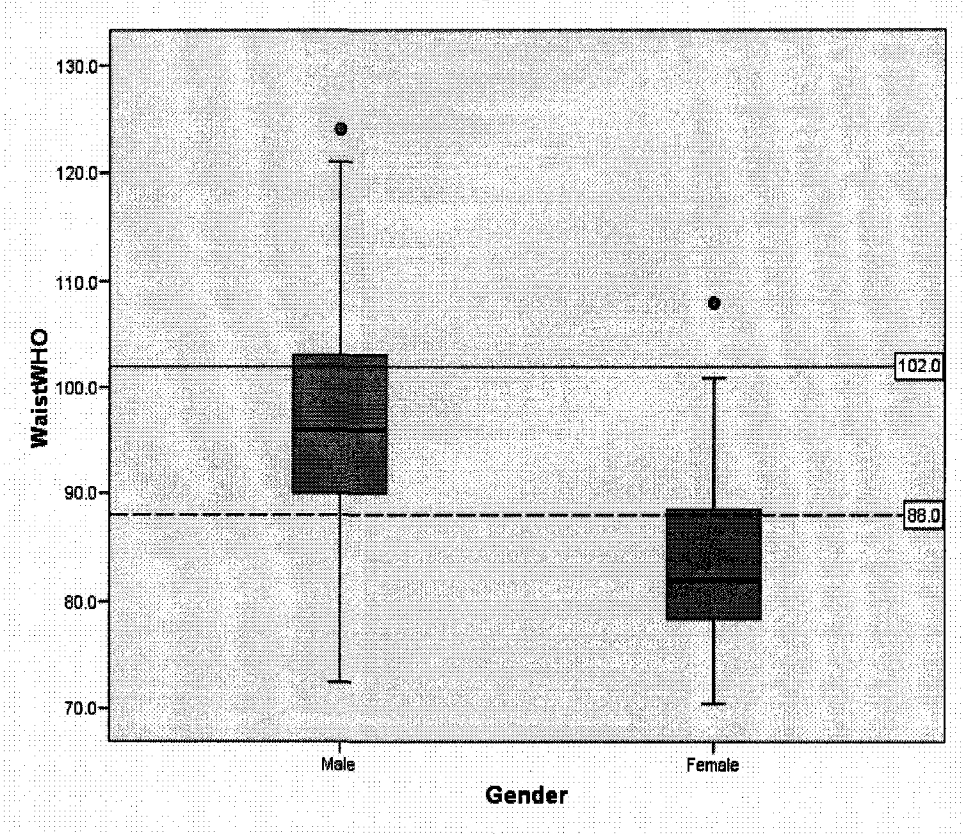
Figure 4.1 BMI Histogram for the Whole Group



4.1.3 BMI Separated by Gender

The data for BMI was divided into sexes and resulted in the sample consisting of 82.5% males (n=127) and 17.5% females (n=27). The mean BMI for females was 25.8 kg/m^2 (SD ± 3.6) and the mean BMI for males of 27.7 kg/m^2 (SD ±3.4), but both sexes on average were classified as overweight by the NIH. Additionally, the BMI for the females ranged from 19.8 kg/m^2 to 33.9 kg/m^2, which was a smaller range and smaller values than demonstrated by the males 21.5 kg/m^2 to 38.6 kg/m^2. From this classification no females were classified as Obese II. However, two males were classified as Obese II. Figure 4.3 demonstrates BMI separated by sex.

Figure 4.2 Boxplot for BMI Separated by Sex

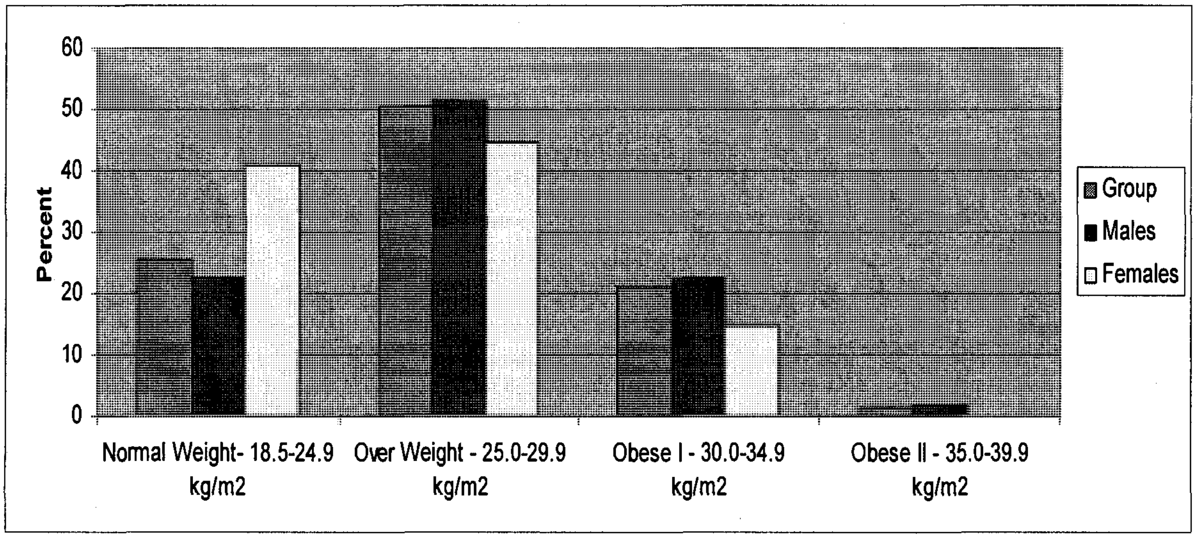


4.1.4 BMI Classifications

All participants were classified according to their NIH BMI. These classifications are shown in Figure 4.3. This classification demonstrated that from the group total (n=154) that 25.9% of the participants were classified as Normal/Healthy Weight (n=40), 51.3% were classified as Overweight (n=79), 21.4% were classified as Obese I (n=33), and 1.3% were classified as Obese II/III (n=2). There were no participants classified as Underweight.

When the participants were separated by sex, 25.5% (n=40) of the males were classified as Healthy/Normal BMI, 50.3% (n=79) as Overweight, 21.0% (n=33) as Obese I, and 1.3% (n=2) as Obese II. The female group had a greater percentage of Healthy/Normal BMI compared to the males with 40.7% (n=11) of the participants falling within this category. Additionally, 44.4% (n=12) were classified as Overweight, 14.8% (n=4) were classified as Obese I, and none were classified as Obese II/III.

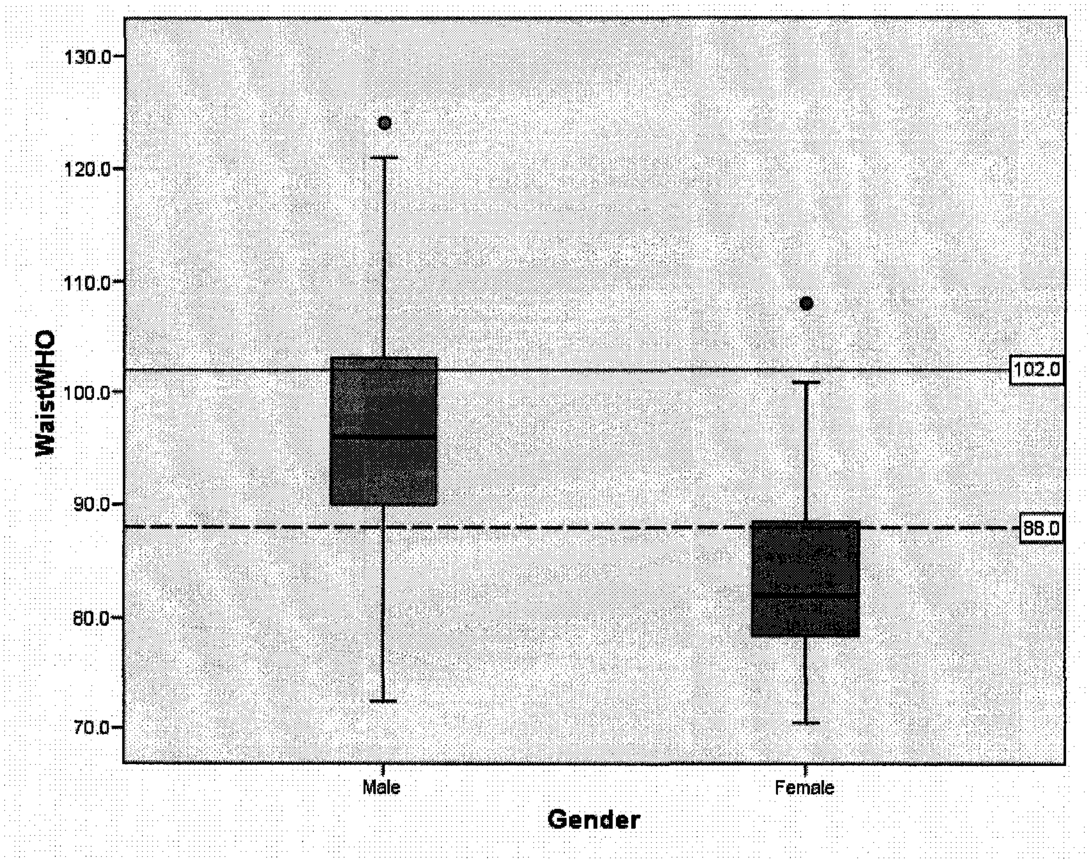
Figure 4.3 BMI Distribution for Whole Group and Sex



4.1.5 WC Descriptive Statistics

A total of 153 participants consented to WC measurements. This sample consisted of 126 males (82.4%) and 27 (17.6%) females. The mean WC for males was 96.99 cm (±9.8 cm, range 72.5 to 124 cm) and the mean WC for the females was 84.5 cm (± 9.3 cm, range 70.5 to 108 cm). As Figure 4.4 demonstrates, the males and females in the high WC classification (i.e. males WC $\geq$ 102 cm and females WC $\geq$ 88 cm) were in approximately the 75th percentile for their sex.

Figure 4.5 Land Evacuation Time when Classified by BMI & WC - Males



4.2 Hypothesis #1

4.2.1 BMI Correlations for 5CT and EXPRES - Whole Group

The BMI for all participants was evaluated via a two-tailed Pearson product-moment correlation to determine if there was a significant correlation between increasing BMI and decreasing performance on the 5CT. Evaluation of BMI with the Land Evacuation, Low High Crawl, and Sandbag Carry ($p > .05$) did not demonstrate any significant correlation. However, a weak but significantly negative correlation was observed between increasing BMI and Sea Evacuation ($p < .01$, $r= -.221$) and BMI and Entrenchment Dig ($p< .05$, $r= -.188$). Each task had a different number of participants as some individuals chose not to attempt or were not able to complete various tasks within the 5CT.

The EXPRES test and BMI were also examined via a two-tailed Pearson product-moment correlation to determine if increasing BMI was associated with poorer performance. This evaluation demonstrated that increasing BMI was positively correlated ($p<.01$) with Handgrip strength ($r=.253$), and Sit Ups ($r= .368$) and negatively correlated with VO2max (as measured from the CAFT step test) ($r= -.267$). It was noted that the correlation between pushups and BMI approached a significant positive correlation ($p=.061$, $r= -.151$). Because the sample of females was so small, the sexes were evaluated separately for performance.

4.2.2 BMI Correlations for 5CT and EXPRES – Males

All participants were separated according to sex and then correlations were reevaluated. The two-tailed Pearson product-moment correlation demonstrated that for males had a significantly positive (p<.01) albeit weak correlation between increasing BMI and increasing time on the Land Evacuation (r = .326), Low High Crawl (r= .250), and a negative correlation with Sandbag Carry (r = -.341). The Sea Evacuation and Entrenchment Dig did not have statistically significant correlations (p>.05). These results indicated that for males, increasing BMI correlated with slower time on the Land Evacuation and Low High Crawl and moving fewer sandbags in the Sandbag Carry.

The correlations for male BMI and EXPRES test were slightly different than the correlations for the whole group comparison. Push Ups, Sit Ups, and VO2max were negatively correlated with BMI (p<.01) a(r= -0.345, -0.414, and -0.567 respectively). However, the correlation between Handgrip and BMI were not significant (p>.05).

4.2.3 BMI Correlations for 5CT and EXPRES – Females

There were fewer numbers of females who attempted or completed the Sea Evacuation (n=20) than the Land Evacuation (n=22), Low High Crawl (n=26), the Entrenchment Dig (n=27) and Sandbag Carry (n=27). Many of the females chose not to attempt various tasks as they believed they were not physically capable of completing the task. This selective performance on tasks combined with an initial small volunteer sample resulted in a sample size that was too small to identify any significant relationships.

In the EXPRES test, there were some statistically significant relationships for the females. Interestingly, VO2max did not correlate with BMI or Push Ups (p> .05). Sit Ups were negatively correlated with BMI (p<.05, r= -.439) and Handgrip strength approach a significant correlation with BMI (p= .075, r= .349). However, caution should be used when interpreting these results as the sample size was too small to have statistical merit.

4.2.4 Analysis of Variance (ANOVA) for Whole Group BMI and 5CT

The participants were classified according to the NIH BMI classification. Participants who were classified as Obese II/III were excluded from analysis as this group only consisted of two participants. The sample size was too small to make any statistical comparisons. However, as demonstrated in Table 4.1 ANOVA for Whole Group BMI and 5CT, there were no significant differences in performance for the whole group between each of the 5CT. However, because females were on average smaller than the males and they required more time to complete the tasks, it was also important to evaluate the differences in performance for each sex.

Table 4.3 ANOVA for Whole Group BMI and 5CT

		N	Mean	Std. Deviation	Significance
Land Evacuation	Normal/Healthy	36	678.6	386.6	0.262
	Overweight	70	627.4	202.1	
	Obese I	29	723.1	253.2	
Sea Evacuation	Normal/Healthy	35	204.1	174.3	0.451
	Overweight	71	172.4	153.9	
	Obese I	30	160.8	85.9	
Sandbag Carry	Normal/Healthy	38	10.8	2.8	0.184
	Overweight	75	11.0	2.0	
	Obese I	33	10.1	1.4	
Entrenchment Dig	Normal/Healthy	36	714.1	372.4	0.174
	Overweight	76	609.9	246.6	
	Obese I	33	614.2	255.3	
Low High Crawl	Normal/Healthy	36	224.2	102.6	0.198
	Overweight	75	209.6	86.5	
	Obese I	32	244.8	95.8	

4.2.5 Analysis of Variance (ANOVA) for BMI and 5CT Separated by Sex

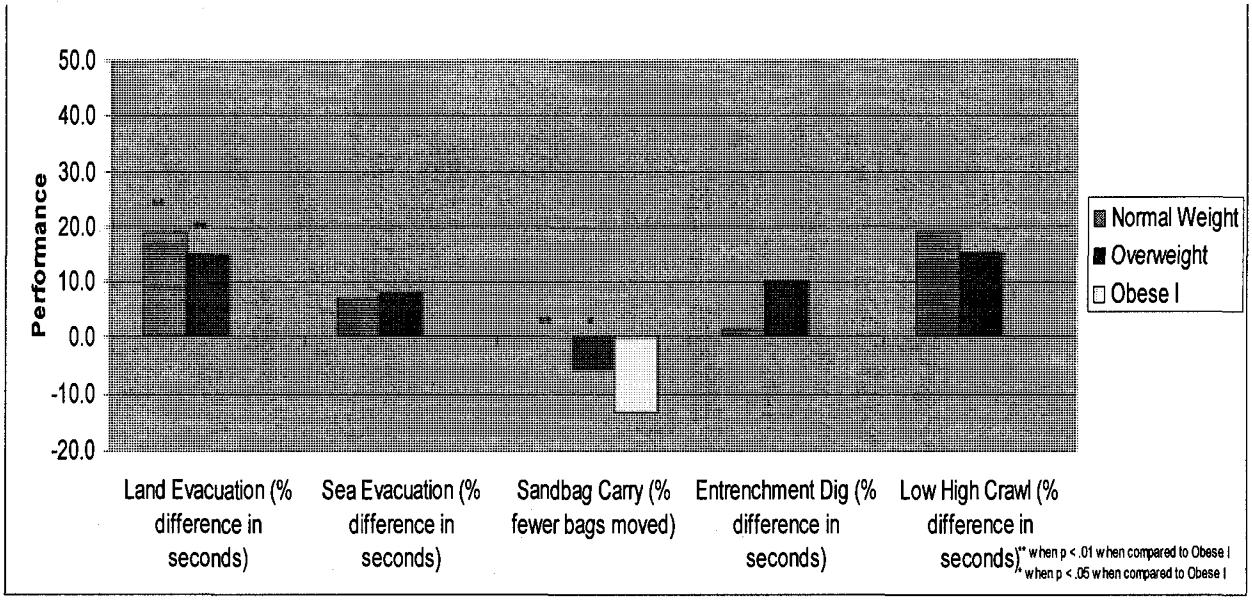
A one-way ANOVA for males demonstrated that there was a significant difference between BMI classifications for the Land Evacuation and Sandbag Carry ($p < .01$). There were no other statistically significant differences in performances for the other 5CT. Tukey's post hoc test was used to determine which BMI classifications had statistically significant differences. In the Land Evacuation there was a statistically significant difference for Healthy/Normal BMI (mean (±SD) 549.6(±124.0) secs) and Obese I (mean (±SD) 678.9(±220.8) secs) as well as between Overweight (mean (±SD) 577.6(±141.8) secs) and Obese I. The participants classified as Healthy/Normal BMI completed the Land Evacuation an average of 129.3 seconds (19.1%) faster than participants classified as Obese I ($p < .01$) while the Overweight participants completed the task 101.3 seconds (14.9%) faster than participants who were classified as Obese I.

In the Sandbag Carry, Healthy/Normal Weight males (mean (±SD) 12.0(±1.9) sandbags) moved an average of 1.6 more sandbags or 13.3% more than participants classified as Obese I (mean (±SD) 10.4(±1.3) sandbags) ($p < .01$). The Overweight participants moved an average of 0.9 more or 7.9% more sandbags (mean (±SD) 11.3(±1.8) sandbagss) (7.9%) than participants who were classified as Obese I ($p < .05$). Table 4.2 demonstrates the differences in performance time for all tasks when classified by BMI classification while Figure 4.5 demonstrates visually the percent differences in performance.

Table 4.4 ANOVA for Males - BMI and 5CT

		N	Mean	Std. Deviation	Significance
Land Evacuation	Normal/Healthy	28	549.6	124.0	.007
	Overweight	61	577.6	141.4	
	Obese I	26	678.9	220.8	
Sea Evacuation	Normal/Healthy	27	140.0	83.3	.772
	Overweight	63	138.5	71.9	
	Obese I	28	150.7	78.1	
Sandbag Carry	Normal/Healthy	29	12.0	1.9	.003
	Overweight	63	11.3	1.8	
	Obese I	29	10.4	1.3	
Entrenchment Dig	Normal/Healthy	27	593.2	297.7	.452
	Overweight	64	542.8	193.4	
	Obese I	29	601.9	267.1	
Low High Crawl	Normal/Healthy	27	187.2	77.5	.098
	Overweight	64	195.9	77.9	
	Obese I	28	230.9	93.5	

Figure 4.5 Land Evacuation Time when Classified by BMI & WC - Males



A one-way ANOVA for females demonstrated that there were no significant differences in performance for each 5CT when separated by BMI classification (Table 4.3). This may have occurred due to the very small sample sizes for each BMI classification. However, it is important to note that for the females, the best performance on each task was not from the Normal/Healthy Weight group. Figure 4.6 shows there was difference in the BMI classification that had the best mean performance for each task. The order of best performance for each task was identified as the following:

- Land Evacuation- Overweight time < Obese I time < Normal/Healthy weight time
- Sea Evacuation – Obese I time < Normal/Healthy time < Overweight time
- Sandbag Carry – Overweight number of sandbags > Obese I number of sandbags > Normal/Healthy number of sandbags
- Entrenchment Dig – Obese I < Overweight time < Normal/Healthy time
- Low High Crawl – Overweight time < Normal/Healthy weight time < Obese I time

Figure 4.6 Percent Difference in 5CT Classified According to BMI – Females

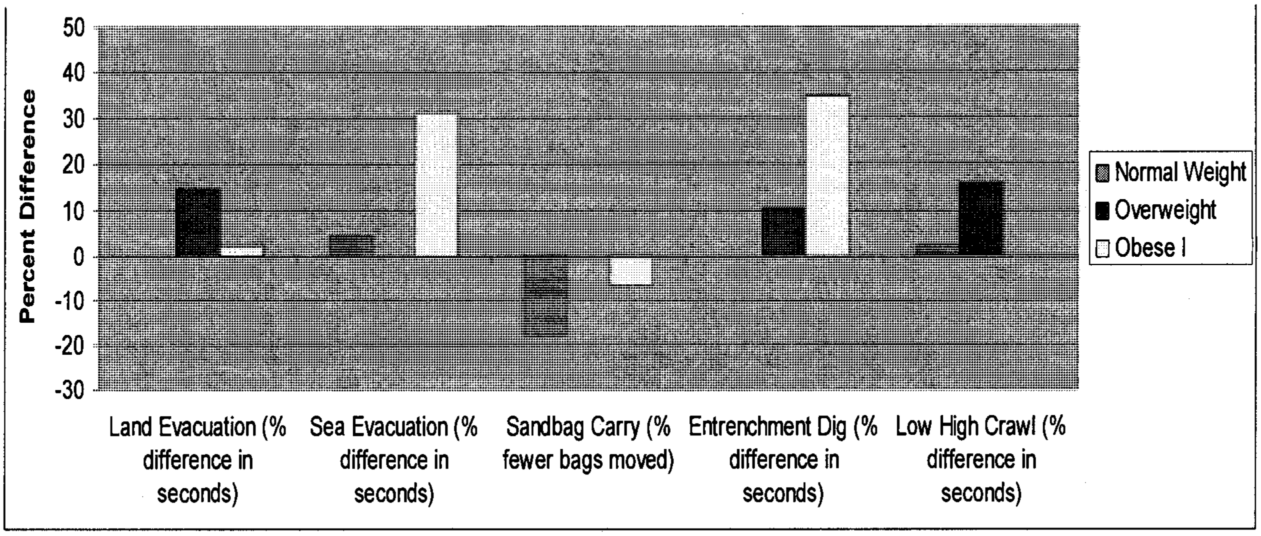


Table 4.5 ANOVA for Females - BMI and 5CT

		N	Mean	Std. Deviation	Significance
Land Evacuation	Normal/Healthy	8	1129.9	623.5	.725
	Overweight	9	965.0	235.0	
	Obese I	3	1105.8	206.4	
Sea Evacuation	Normal/Healthy	8	420.2	229.5	.809
	Overweight	8	439.5	315.0	
	Obese I	2	301.8	79.8	
Sandbag Carry	Normal/Healthy	9	7.3	2.4	.166
	Overweight	12	8.9	1.7	
	Obese I	4	8.3	1.2	
Entrenchment Dig	Normal/Healthy	9	1077.0	348.3	.069
	Overweight	12	967.6	186.5	
	Obese I	4	703.3	130.9	
Low High Crawl	Normal/Healthy	9	335.3	89.3	.411
	Overweight	11	289.3	94.7	
	Obese I	4	342.7	41.5	

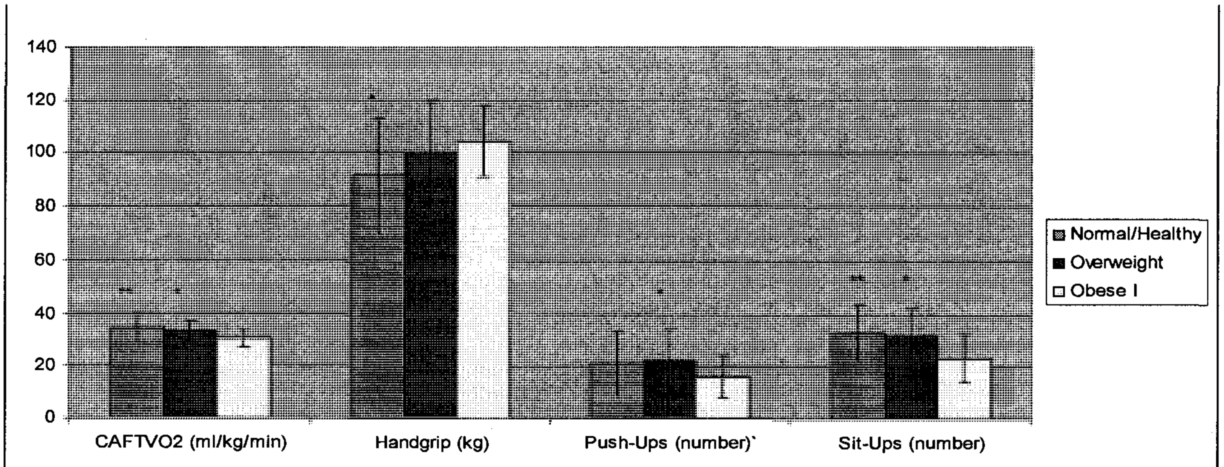
4.2.6 Analysis of Variance (ANOVA) for Whole Group BMI and EXPRES

The whole group also evaluated by NIH classification and EXPRES test performance. Participants who were classified as Obese II/III were excluded from analysis as this group only consisted of two participants. The sample size was too small to make any statistical comparisons. As Table 4.4 demonstrates, a one-way ANOVA demonstrated significant differences in performance for the whole group between each component of the EXPRES test. Tukey's post hoc test then identified the BMI Classifications that demonstrated statistically significant differences. These differences are displayed in Graph 4.8. This analysis indicated that the Normal/Healthy BMI group had VO2max (34.5(±5.2) ml/kg/min) that was 1.5 ml/kg/min better than Obese I ($p < .05$) and that they performed 10 more Sit Ups than the Obese I group ($p < .01$), but that they had a combined Handgrip score that was 10.8 kg less than the Obese I group. The Overweight group also had a better VO2max (32.99(4.4) ml/kg/min), Push Ups score (mean(±SD), 22(12)), and better Sit Ups score (mean(±SD), 32(10)) than for the Obese I ($p< .05$) group (VO2max 30.5(±3.1) ml/kg/min, 16(±8) Push Ups, and 23(±9) Sit Ups. The statistical difference in handgrip was not significant, but again the mean was better for the Obese I than the Overweight group. The values are displayed in Table 4.4 and are graphically displayed in Figure 4.7.

Table 4.6. ANOVA for BMI and EXPRES- Whole Group

		N	Mean	Std. Deviation	Significance
VO2max	Normal/Healthy	38	34.5	5.2	.001
	Overweight	77	32.99	4.4	
	Obese I	32	30.5	3.1	
Handgrip	Normal/Healthy	38	91.5	21.4	.016
	Overweight	77	99.7	19.8	
	Obese I	33	104.3	13.1	
Push-Ups	Normal/Healthy	38	21	12	.036
	Overweight	77	22	12	
	Obese I	33	16	8	
Sit-Ups	Normal/Healthy	38	33	11	.000
	Overweight	77	32	10	
	Obese I	33	23	9	

Figure 4.7 EXPRES Results Classified by BMI Classification – Whole Group



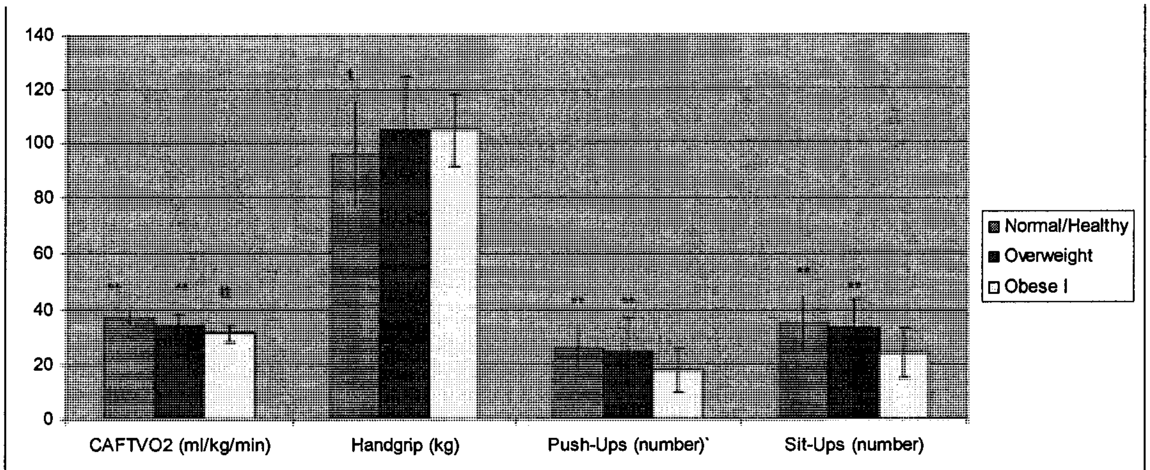
Significantly different than Obese I at **p < .01
Significantly different than Obese I at *p < .05

4.2.7 Analysis of Variance (ANOVA) for BMI and EXPRES Separated by Sex

Performance on the EXPRES test according to BMI classification was also conducted on the sexes separately. For the males, statistically significant differences were identified on all components of the EXPRES test. These differences are displayed in Figure 4.8 and demonstrate the following:

- VO2max– The Normal/Healthy BMI had a significantly better ($p < .01$) VO2max (36.8 (±2.9) ml/kg/min) than the Overweight (34.1 (±3.5) ml/kg/min) and Obese I ($p < .01$) and that the Overweight group also had a significantly better VO2max than the Obese I group (31.3 (±2.3 ml/kg/min).
- Handgrip – The Overweight group had significantly better ($p < .05$) handgrip strength (104.5(±15.2) kg) than the Normal/Healthy BMI group (95.4 (±19.2) kg) and that handgrip strength for the Obese I group (104.7 (±12.5) kg) nearly approached statistical significance when compared to the Overweight group.
- Push ups – Both the Normal/Healthy BMI group (26(±9) Push Ups) and Overweight group (25(±11) Push Ups) were able to complete more pushups than the Obese I group (18(± 7) Push Ups) ($p < .01$), but That there was not a statistically significant difference between "Normal/Healthy" BMI and "Overweight" BMI.
- Sit Ups - Both the Normal/Healthy BMI group (34(±10) Sit ups) and the Overweight group (33(±10) Sit Ups) were able to complete more Sit Ups than the Obese I group (23(± 8) Sit Ups) ($p < .01$).

Figure 4.8 EXPRES Results by BMI Classification – Males



Significantly different than Obese I at **p < .01, Significantly different than Overweight at ‡‡ p < .01
Significantly different than Obese I at *p < .05, Significantly different than Overweight at ‡ p < .05

Surprisingly, there were no statistically significant differences in performance for females when they were separated according to BMI classification. Additionally, in comparison to participation levels for the females in the 5CT, in the EXPRES test, all females completed all components of the test. The results for the female participants are displayed in Table 4.5.

Table 4.7. ANOVA for BMI and EXPRES- Females

Females		N	Mean	Std. Deviation	Significance
VO2max	Normal/Healthy	9	27.1	3.7	.553
	Overweight	12	26.9	3.2	
	Obese I	4	25.1	2.0	
Handgrip	Normal/Healthy	9	78.9	24.5	.124
	Overweight	12	73.5	22.1	
	Obese I	4	101.5	19.5	
PushUp	Normal/Healthy	9	5	5	.219
	Overweight	12	8	5	
	Obese I	4	4	4	
SitUp	Normal/Healthy	9	27	12	.205
	Overweight	12	26	9	
	Obese I	4	16	12	

4.3 Hypothesis #2

The participants were separated by sex, so that analysis of WC correlations could be conducted. The participants were categorized by NIH WC groups where males were classified as High WC if their WC was greater than or equal to 102 cm and as Low WC if their WC was less than 102 cm. The females were classified as High WC if their WC was greater than or equal to 88 cm and as Low WC if their WC was less than 88 cm.

4.3.1 Waist Circumference Correlations for Five Common Tasks

A two-tailed, Pearson product-moment correlation demonstrated that there was not a significant correlation for increasing WC for females on any of the 5CT. This is likely due to the small sample size. For the males, there was a significant correlation with Land Evacuation time ($r= .351$), Low High Crawl time ($r= .348$), and the number of sandbags moved in the Sandbag Carry ($r= -.349$) ($p< .001$). These correlations are displayed in Figures 4.9, 4.10, and 4.11,, respectively. This indicates that males in the high WC group (associated with increased health risk) were slower on the Lowh High Crawl, the Land Evacuation, and moved fewer sandbags in the Sandbag Carry.

Figure 4.9 Correlation for WC and Evacuation - Males

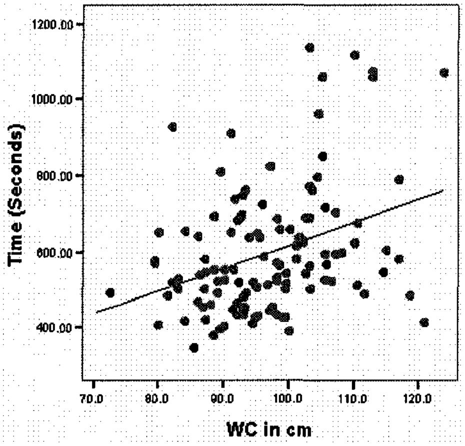


Figure 4.10 Correlation for WC and Sandbag - Males

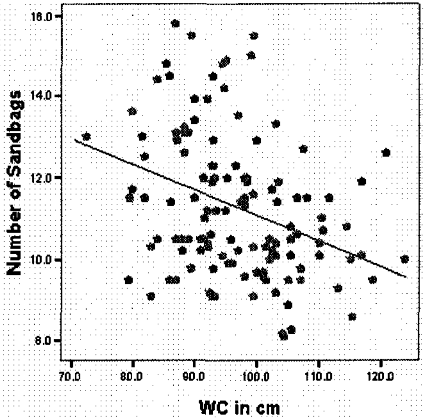
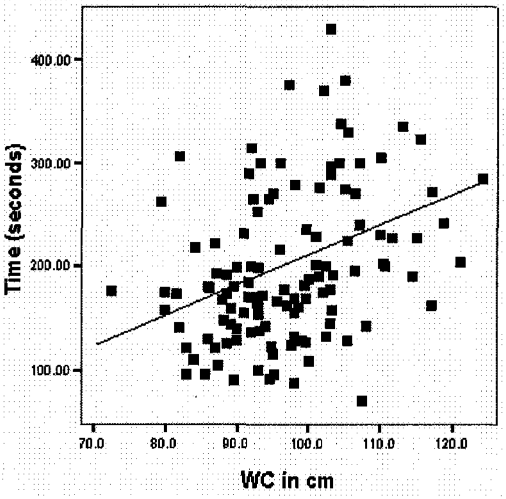


Figure 4.11 Correlation for WC and Low High Crawl - Males



4.3.2 Waist Circumference Correlations for EXPRES test

A two-tailed, Pearson product-moment correlation was used to determine if WC correlated to performance on the EXPRES test for males and females. Similar to the correlations for 5CT and WC for females, there were no significant correlations between females WC and values in the EXPRES test. However, for the males, increasing WC was significantly correlated ($p < .01$) with decreasing VO2max ($r= -.586$), number of Push Ups ($r= -.528$), and number of Sit Ups ($r= -.424$). The handgrip test showed a very small($r= .098$) , but significantly positive correlation, which demonstrated that increasing WC was correlated with increasing handgrip strength ($p < .01$). The stronger, statistically significant correlations are displayed in Figures 4.12, 4.13, and 4.14, respectively.

Figure 4.12. VO2max Correlation with WC - Males

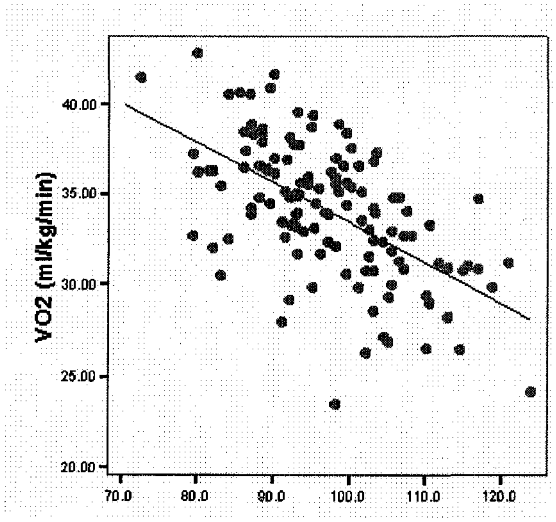


Figure 4.13. Push-Up Correlation with WC - Males

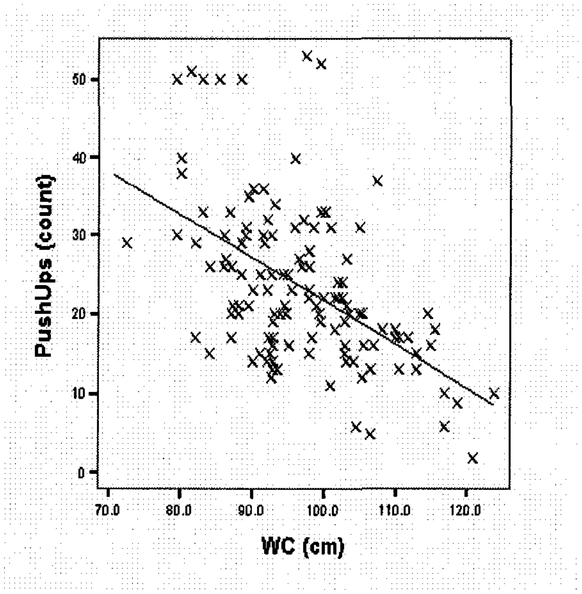
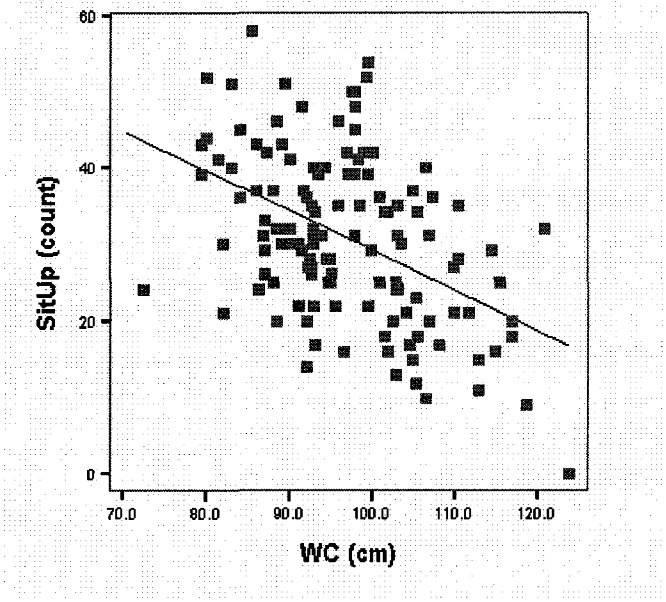


Figure 4.14. Sit UPs Correlation with WC - Males



4.3.3 Comparison of WC Classifications for 5CT

A two-tailed independent t-test was conducted for each sex separately to determine if there was a statistically significant difference between the High and Low WC classifications. For the males, Levene's test of equality of variances demonstrated that only in the Entrenchment Dig wwas equality of variance assumed; for all other tests, equality of variance was not assumed. As Table 4.6 demonstrates, performance was statistically better for males in the Low WC group than the High WC group for the Land Evacuation, Sandbag Carry, Low High Crawl ($p < .01$), Entrenchment Dig ($p < .05$), and approached significant improvements for the Sea Evacuation. The percent difference in time between the groups was also analysed. As Figure 4.15 demonstrates, males classified as having a Low WC ranged from 13.6% on the Sandbag Carry to 26.9% faster performance on Low High Crawl.

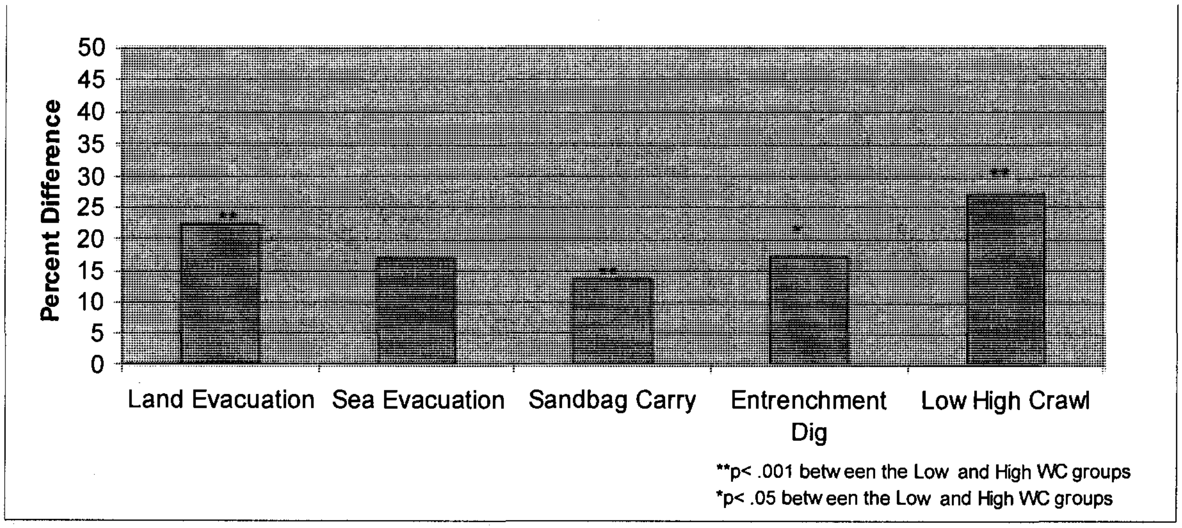
Table 4.8. Performance in 5CT for Males Classified by High or Low WC

	WC Classification	N	Mean	Std. Deviation	
Land Evacuation	Low WC	82	549.5	122.5	**.000
	High WC	36	706.8	205.7	
Sea Evacuation	Low WC	82	132.8	69.0	.085
	High WC	39	160.2	85.1	
Sandbag Carry	Low WC	84	11.7	1.8	**.000
	High WC	40	10.3	1.3	
Entrenchment Dig	Low WC	83	535.3	214.8	*.013
	High WC	40	647.5	263.4	
Low High Crawl	Low WC	83	181.1	68.4	**.000
	High WC	39	248.0	90.3	

* Significant at the 0.05 level (2-tailed).

** Significant at the 0.01 level (2-tailed).

Figure 4.15. Percent Difference in 5CT Performance for Low WC and High WC – Males



As Table 4.7 demonstrated, the number of female participants varied by each task. Levene's test of equality of variances demonstrated that unequal variances were assumed for the Sea Evacuation and Low High Crawl. Equal variances were assumed for the other tests. However, for the females there were no significant differences between the Low WC and High WC groups.

Table 4.9. Performance in 5CT for Females Classified by High or Low WC

	WC Classification	N	Mean	Std. Deviation	
Land Evacuation	Low WC	16	1085.7	482.2	.718
	High WC	6	1010.9	169.1	
Sea Evacuation	Low WC	15	494.5	317.7	.068
	High WC	5	323.2	71.0	
Sandbag Carry	Low WC	20	7.9	2.2	.302
	High WC	7	8.8	1.1	
Entrenchment Dig	Low WC	20	1015.8	328.2	.259
	High WC	7	860.8	218.8	
Low High Crawl	Low WC	19	320.9	118.2	.709
	High WC	7	332.2	34.1	

4.3.4 Comparison of WC Classifications for EXPRES

Comparison of performance on the EXPRES test for High WC and Low WC groups were performed via a two-tailed independent t-test for both males and females. For the males there were 86 participants in the Low WC group and 40 in the High WC group. Levene's test of variance showed that variances were unequal for the push ups, but equal for all other groups. This analysis demonstrated that performance was better for males in the Low WC group for VO2max, Push Ups, and Situps ($p< .01$), but that there was no difference in performance for Handgrip between the two groups. For the females, the Low WC was composed of 20 participants, and the High WC of 7 participants. Levene's Test showed that variances were equal. However, there were no statistically significant differences between the Low or High WC for any of the EXPRES components.

Table 4.10 T-test for High and Low WC Separated by Sex

		WC Classification	Mean	Std. Deviation	Significance
VO2max	Males	Low WC	35.4	3.2	.000
		High WC	31.1	2.9	
	Females	Low WC	27.1	3.4	.219
		High WC	25.4	1.8	
Handgrip	Males	Low WC	101.5	17.1	.664
		High WC	102.9	12.6	
	Females	Low WC	77.5	23.8	.211
		High WC	90.7	22.1	
PushUp	Males	Low WC	26	10	.000
		High WC	17	7	
	Females	Low WC	7	6	.345
		High WC	5	5	
SitUp	Males	Low WC	35	10	.000
		High WC	23	9.0	
	Females	Low WC	28	11	.078
		High WC	19	10	

4.4 Hypothesis #3

All participants were separated by sex. They were then classified as one of the following groups:

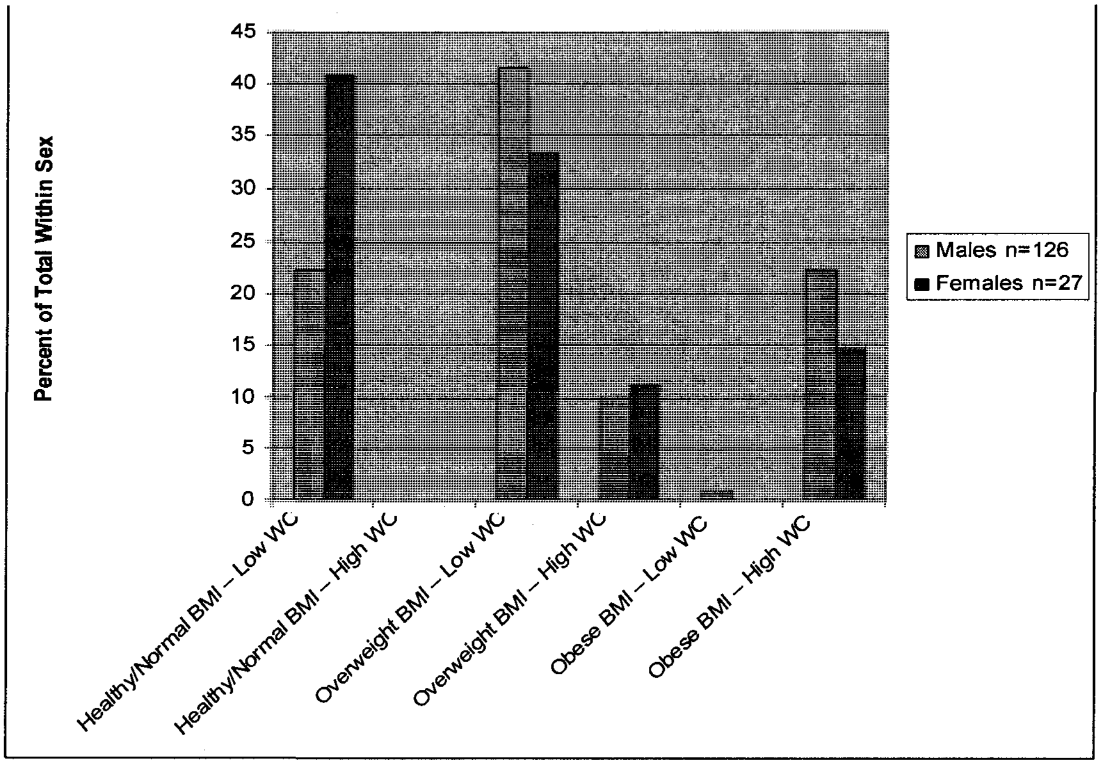
- Healthy/Normal BMI – Low WC
- Healthy/Normal BMI – High WC
- Overweight BMI – Low WC
- Overweight BMI – High WC
- Obese BMI – Low WC
- Obese BMI – High WC

This classification was performed for 126 males and 27 females separately. Table 4.9 shows the number of males and females in each category while Figure 4.16 demonstrates the percent of the sex total for each classification. There were no participants classified as Underweight, no females classified as Obese I/II, LWC and only one male in the Obese I/II, LWC therefore these classifications were excluded from analysis of variance for both 5CT and EXPRES.

Table 4.11 Number of Males and Females Classified by BMI and WC

	Number of Males	Number of Females
Healthy/Normal BMI, LWC	29	11
Healthy/Normal BMI, HWC	0	0
Overweight, LWC	54	9
Overweight, HWC	13	3
Obese (I,II), LWC	1	0
Obese (I,II), HWC	29	4

Figure 4.16 Distributions of BMI Classification and WC Classification- Separated by Sex



4.4.1 Combined BMI and WC Classification - Five Common Tasks

The descriptive statistics for males classified according to BMI and WC and their performance in the 5CT are displayed in Table 4.10. The data was then analyzed via a one-way analysis of variance (ANOVA) where a significance of 0.05 was used to demonstrate significant differences within and between the categories. Low WC was excluded during the ANOVA due to sample size. Significant differences were identified in the Land Evacuation, Sandbag Carry, Low High Crawl ($p < .01$), and Entrenchment Dig ($p < .05$). There were no differences between the groups identified for the Sea Evacuation.

Tukey's post hoc test was then used to determine, which categories had statistically different performances. These significant differences are displayed in Table 4.11. As Figure 4.17 shows, for the Land Evacuation, it was determined that the both the Healthy BMI, Low WC (549.6±(124.0) seconds) and Overweight BMI, Low WC (547.3(±124.6) seconds) classifications performed the Land Evacuation faster than males with classified as Overweight, High WC (715.9(±122.9) seconds) and Obese (I/II) BMI, High WC (700.0(±230.9) seconds). These differences were all significant at p < .01.

Table 4.12. Male Combined BMI and WC Classification for the 5CT

		N	Mean	Std. Deviation	Significance
Land Evacuation	Healthy/Normal BMI – Low WC	28	549.6	124.0	**.000
	Overweight BMI – Low WC	52	547.3	124.6	
	Overweight BMI – High WC	11	715.9	122.9	
	Obese BMI – High WC	26	700.	230.9	
	Obese BMI – Low WC	1	571.12		
Sea Evacuation	Healthy/Normal BMI – Low WC	27	140.0	83.3	.270
	Overweight BMI – Low WC	52	129.3	62.5	
	Overweight BMI – High WC	13	169.9	94.0	
	Obese BMI – High WC	28	153.8	79.8	
	Obese BMI – Low WC	1	112.9		
Sandbag Carry	Healthy/Normal BMI – Low WC	29	12.0	1.9	**.000
	Overweight BMI – Low WC	52	11.6	1.8	
	Overweight BMI – High WC	13	10.2	1.4	
	Obese BMI – High WC	29	10.3	1.2	
	Obese BMI – Low WC	1	11.3		
Entrenchment Dig	Healthy/Normal BMI – Low WC	27	593.2	297.7	*.038
	Overweight BMI – Low WC	53	508.6	157.8	
	Overweight BMI – High WC	13	688.0	246.4	
	Obese BMI – High WC	29	620.2	268.1	
	Obese BMI – Low WC	1	426.0	.	
Low High Crawl	Healthy/Normal BMI – Low WC	27	187.2	77.5	**.000
	Overweight BMI – Low WC	53	176.2	64.4	
	Overweight BMI – High WC	13	270.9	79.6	
	Obese BMI – High WC	28	236.3	91.8	
	Obese BMI – Low WC	1	168.9	.	

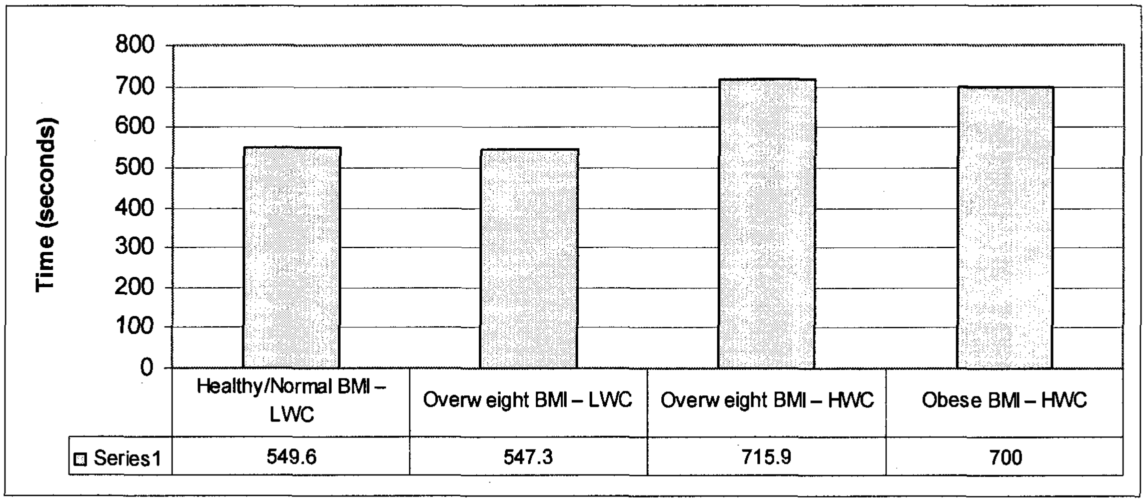
* The mean difference is significant at the .05 level.

** The mean difference is significant at the .01 level.

Table 4.13. Significant Differences in BMI and WC Classifications for 5CT - Males			
		Overweight, HWC	Obese I/II, HWC
Healthy/Normal, LWC	Land Evacuation	**.016	**.003
	Low High Crawl	**.008	.084
	Sandbag Carry	*.012	**.002
Overweight, LWC	Land Evacuation	**.007	**.000
	Low High Crawl	**.001	**.005
	Sandbag Carry	*.043	**.006
	Entrenchment Dig	.065	

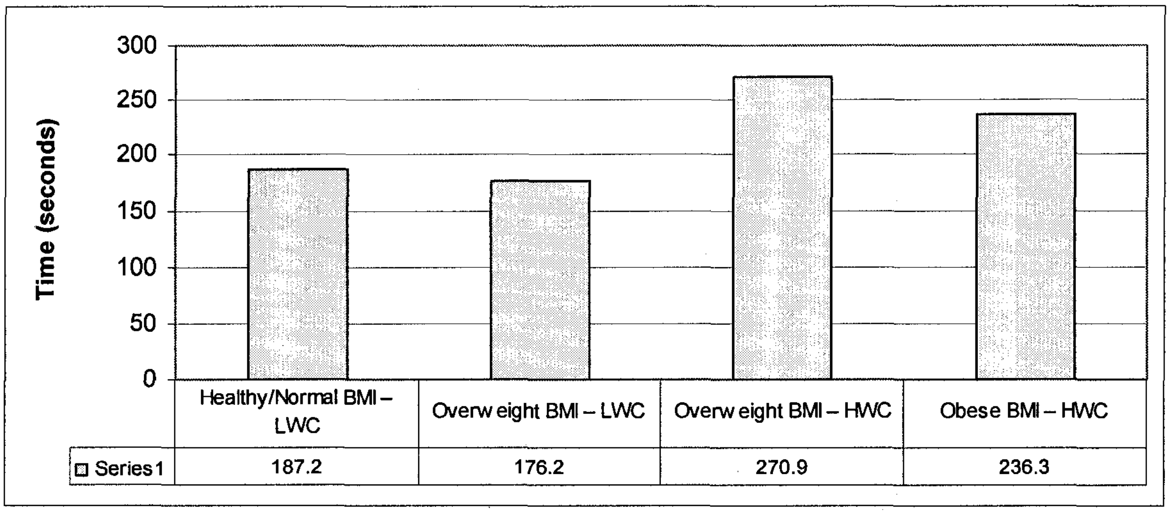
** The mean difference is significant at the .01 level.

Figure 4.17 Land Evacuation Time When Separated by the Combination of BMI and WC Classifications - Males



In the Low High Crawl Healthy/Normal BMI, Low WC (187.2 (±77.5) seconds) and Overweight BMI, Low WC (176.2(±64.4) seconds) classifications performed the Land Evacuation faster than males with classified as Overweight, High WC (270.9 (±79.6) seconds) and Obese (I/II) BMI, High WC (263.3(±91.8) seconds), but performance for the Healthy BMI, Low WC group only approached statistical significance with the Obese (I/II), High WC group (p < .10). These differences are demonstrated in Figure 4.18.

Figure 4.18 Low High Crawl Time When Separated by the Combination of BMI and WC Classifications - Males



In the Entrenchment Dig, there were no statistically significant differences between the groups. However, the Overweight BMI and Low WC group approached statistical significance with the Obese (I/II) High WC group. These differences are demonstrated in Figure 4.19.

The descriptive statistics for females classified according to BMI and WC and their performance in the 5CT are displayed in Table 4.12. The ANOVA for females demonstrated that there were no significant differences between or within any of the groups.

Figure 4.19 Entrenchment Dig Time When Separated by the Combination of BMI and WC Classifications - Males

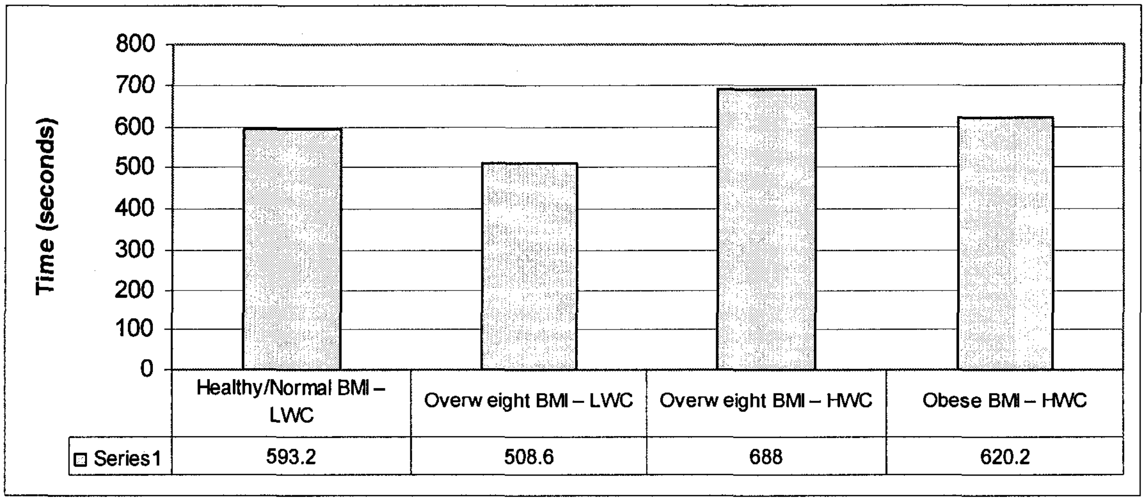


Table 4.14. Female Combined BMI and WC Classification for the 5CT

		N	Mean	Std. Deviation	Significance
Land Evacuation	Healthy/Normal BMI – Low WC	9	1098.6	590.7	.908
	Overweight BMI – Low WC	6	989.5	292.3	
	Overweight BMI – High WC	3	916.0	43.3	
	Obese BMI – High WC	3	1105.8	206.4	
Sea Evacuation	Healthy/Normal BMI – Low WC	9	423.8	215.0	.757
	Overweight BMI – Low WC	5	500.7	397.5	
	Overweight BMI – High WC	3	337.5	78.3	
	Obese BMI – High WC	2	301.8	79.8	
Sandbag Carry	Healthy/Normal BMI – Low WC	10	7.5	2.3	.351
	Overweight BMI – Low WC	9	8.7	1.9	
	Overweight BMI – High WC	3	9.5	0.8	
	Obese BMI – High WC	4	8.3	1.2	
Entrenchment Dig	Healthy/Normal BMI – Low WC	10	1024.6	367.8	.224
	Overweight BMI – Low WC	9	933.1	204.8	
	Overweight BMI – High WC	3	1070.9	45.1	
	Obese BMI – High WC	4	703.3	130.9	
Low High Crawl	Healthy/Normal BMI – Low WC	10	326.5	88.6	.593
	Overweight BMI – Low WC	8	278.4	110.4	
	Overweight BMI – High WC	3	318.3	19.8	
	Obese BMI – High WC	4	342.7	41.5	

4.4.2 Males Combined BMI and WC Classification - EXPRES

The descriptive statistics for males classified according to BMI and WC and their performance in the EXPRES are displayed in Table 4.13. A one-way analysis of variance (ANOVA) with a significance of 0.05 was used to demonstrate significant differences within and between the categories. The category Obese BMI, Low WC was excluded during the ANOVA due to sample size. Significant differences were identified in the VO2max, Push Ups, and Sit Ups (p < .001), but no statistical differences were observed in the Handgrip scores for males. Tukey's post hoc test was then used to determine, which categories had statistically different performances. The statistical differences between each statistically significant group are displayed in Table 4.13. Only the Handgrip test did demonstrate statistical difference between the classifications.

Table 4.15. Male Combined BMI and WC Classification for the EXPRES test

		N	Mean	Std. Deviation	Significance
VO2max	Healthy/Normal BMI – Low WC	29	36.8	2.9	.000
	Overweight BMI – Low WC	54	34.8	3.2	
	Overweight BMI – High WC	13	31.5	3.5	
	Obese BMI – High WC	29	31.1	2.7	
	Obese BMI – Low WC	1	32.1	.	
Handgrip	Healthy BMI, LWC	29	95.4	19.1	.095
	Overweight, LWC	54	104.2	15.4	
	Overweight, HWC	13	103.7	14.3	
	Obese (I,II), HWC	29	103.1	12.2	
	Obese LWC	1	115.0	.	
PushUp	Healthy/Normal BMI – Low WC	29	26.0	9	.000
	Overweight BMI – Low WC	54	27	11	
	Overweight BMI – High WC	13	17	6	
	Obese BMI – High WC	29	17	7	
	Obese BMI – Low WC	1	28		
SitUp	Healthy/Normal BMI – Low WC	29	35	10	.000
	Overweight BMI – Low WC	54	35	10	
	Overweight BMI – High WC	13	23	8	
	Obese BMI – High WC	29	23	9	
	Obese BMI – Low WC	1	31	.	

* The mean difference is significant at the .05 level.

** The mean difference is significant at the .01 level.

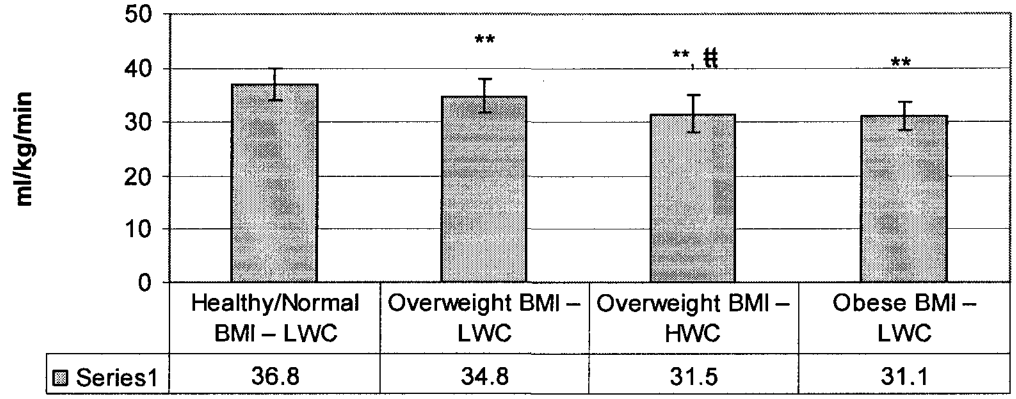
Table 4.16. Significant Differences in BMI and WC Classifications for EXPRES - Males

		Obese (I/II), HWC	Overweight, HWC	Overweight, LWC
Healthy BMI, LWC	VO2max	**.000	**.000	*.023
	Handgrip		.074	
	Push Up	**.001	*.012	
	Sit Ups	**.000	**.004	
Overweight, LWC	VO2max	**.000	**.005	
	Handgrip			
	Push Up	**.000	**.002	
	Sit Ups	**.000	**.001	

* The mean difference is significant at the .05 level.

The VO2max for males classified as having a Healthy/Normal BMI, Low WC (mean (±SD) 36.8 (±2.9) ml/kg/min, range 31.99 to 42.81 ml/kg/min) was statistically better than males classified as Overweight, Low WC (mean (±SD) 34.8 (±3.2) ml/kg/min, range 23.5 to 40.6 ml/kg/min) (p <.05), than males who are Overweight, High WC (mean (±SD) 31.5(3.5) ml/kg/min, range 26.3 to 37.3 ml/kg/min (p< .01), and males who are Obese (I/II), High WC (mean(±SD) 31.1(2.7) ml/kg/min, range 27.2 to 34.8 ml/kg/min) (p<.001). Additionally, males who were Overweight, Low WC also had a statistically better VO2 max than males who were Overweight, High WC and better than males who were Obese (I/II), High WC. The differences in VO2max are displayed in Figure 4.20.

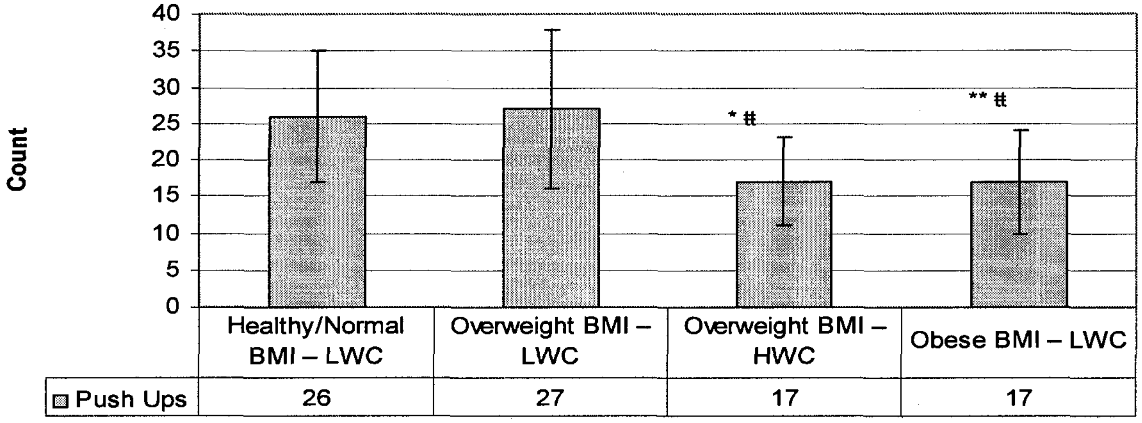
Figure 4.20 VO2max Classified by BMI and WC – Males



**p< .001 when compared to Healthy BMI, Low WC ,‡‡p<.001 when compared to Overweight BMI, Low WC

The Push Ups test for males showed that the Healthy BMI with Low WC group (mean (±SD) 27(±11), range 13 to 50) completed a statistically significant, greater number of push ups than the Overweight with High WC group (p< .05) (mean (±SD) 17(±6), range 5 to 22) and Obese (I/II) with High WC group (p < .01) (mean (±SD) 17(±7) range 2 to 27). The Overweight with Low WC (mean (±SD) 27(±11), range 11 to 53) group also had a better performance than the Overweight with High WC and Obese (I/II) with High WC (p < .01). These differences are displayed in Figure 4.21.

Figure 4.21 Push Ups Classified by BMI and WC - Males

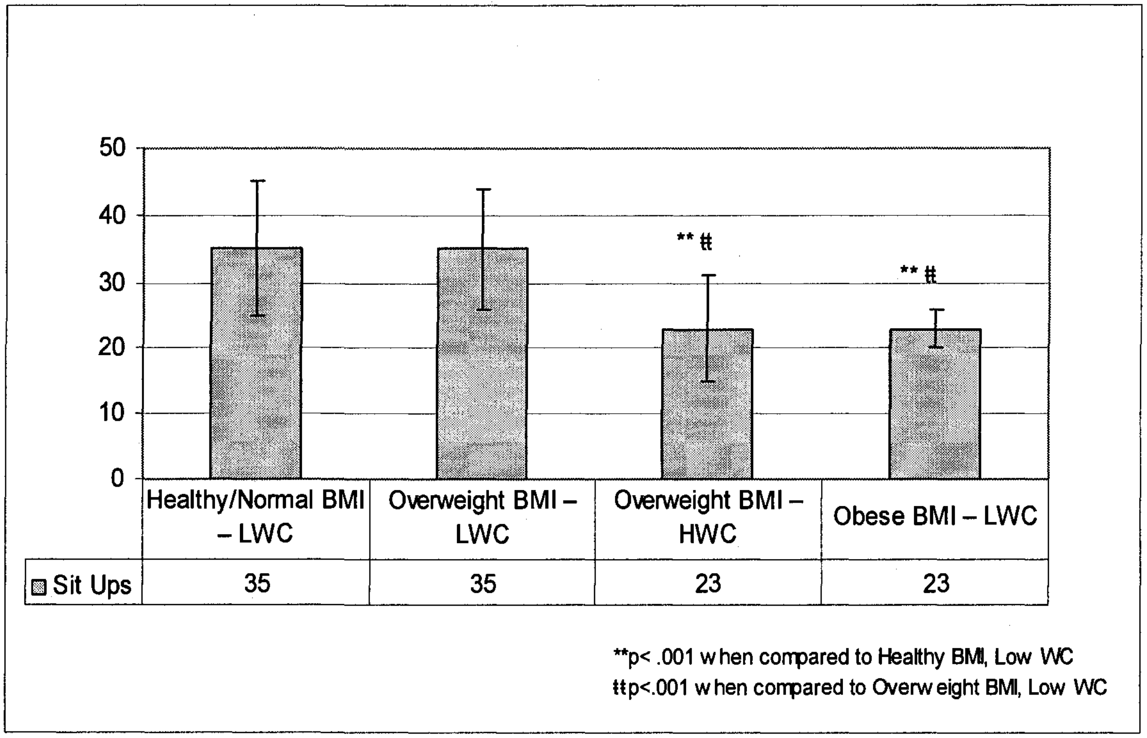


	Healthy/Normal BMI – LWC	Overweight BMI – LWC	Overweight BMI – HWC	Obese BMI – LWC
▨ Push Ups	26	27	17	17

*p<.05 when compared to Healthy BMI, Low WC; **p< .001 when compared to Healthy BMI, Low WC; ‡‡p<.001 when compared to Overweight BMI, Low WC

Finally, the Sit Ups test showed statistically significant differences between the Healthy BMI and Low WC group (mean (±SD) 35(±10), range 17 to 52) and the Overweight with High WC group (mean (±SD) 23(±8), range 10 to 35) (and the Obese (I/II) with High WC group (mean (±SD) 23(±9), range 2 to 37) (p<.01). The Overweight with Low WC group (mean (±SD) 35(±10), range 11 to 53) also demonstrated a statistically better performance than the Overweight with High WC and the Obese (I/II) with High WC group (p< .01). These differences are displayed in Figure 4.22.

Figure 4.22 Sit Ups Classified by BMI and WC - Separated by Sex



**p< .001 when compared to Healthy BMI, Low WC
‡‡p<.001 when compared to Overweight BMI, Low WC

Analysis was also performed for females when classified by BMI and WC and performance in the EXPRES test. However, as Table 4.15 shows, a one-way ANOVA with a significance level of 0.05 did not demonstrate any statistically significant differences in performance between or within the groups.

Table 4.17. Female Combined BMI and WC Classification for the EXPRES test

		N	Mean	Std. Deviation	Significance
VO2max	Healthy/Normal BMI – Low WC	10	27.2	3.5	.657
	Overweight BMI – Low WC	9	27.2	3.6	
	Overweight BMI – High WC	3	25.9	1.6	
	Obese BMI – High WC	4	25.1	2.0	
Handgrip	Healthy/Normal BMI – Low WC	10	82.1	25.2	.258
	Overweight BMI – Low WC	9	72.6	24.1	
	Overweight BMI – High WC	3	76.3	18.8	
	Obese BMI – High WC	4	101.5	19.5	
Push Up	Healthy/Normal BMI – Low WC	10	5	5	.352
	Overweight BMI – Low WC	9	9	4	
	Overweight BMI – High WC	3	6	6	
	Obese BMI – High WC	4	4	4	
Sit Up	Healthy/Normal BMI – Low WC	10	28	11	.298
	Overweight BMI – Low WC	9	26	10	
	Overweight BMI – High WC	3	24	5	
	Obese BMI – High WC	4	16	12	

4.5 Hypothesis #4

Hypothesis #4 that lower aerobic capacity, muscular strength, and muscular endurance as measured in the CF EXPRES test is associated with poorer performance in the Five Common Tasks was tested by using a two-tailed, Pearson product-moment correlation. A significance level of 0.05 was used to identify statistically significant correlations between VO2max and score on the Handgrip, Push Ups, and Sit Ups tests and performance on the 5CT. Analysis was first conducted for the whole group and then further analyzed for the sexes. Missing values were excluded case by case.

4.5.1 EXPRES and 5CT Correlations – Whole Group

For the whole group, VO2max was significantly correlated with (p < .01) with Land Evacuation (r= -.698), Sea Evacuation (r= -.559), Entrenchment Dig (r = -.601), Low High Crawl (r= -.649), and Sandbag Carry (r= .722). Handgrip was also significantly correlated (p < .01) with Land Evacuation (r= -.303), Sea Evacuation (r= -.325), Entrenchment Dig (r = -.325), Low High Crawl (r= -.210), and Sandbag Carry (r= .252), although the correlations were weaker than with VO2max. Push Ups were also significantly correlated (p<.01) with Land Evacuation (r -.464), Sea Evacuation (r= -.359), Entrenchment Dig (r= -.421), Low High Crawl (r= -.449), and Sandbag Carry (r= .459). Only the Sit Ups were not correlated with all of the 5CT. Sit Ups were not were not significantly correlated with the Sea Evacuation (p>.05), but they did correlate (p< .01) with Land Evacuation (r= -0.414), Entrenchment Dig (r = -.253), Low High Crawl (r= -.325), and Sandbag Carry (r= .335). However, because there were significant differences in performance on the CF EXPRES test for the sexes, analysis was also conducted for each sex independently.

4.5.2 EXPRES and 5CT Correlations – Males

For the males, VO2max was a significant correlation (p < .01) with Land Evacuation (r= -.563), Sea Evacuation (r= -.439), Entrenchment Dig (r=-.433), Low High Crawl (r= -.552), and Sandbag Carry (r= .630). Handgrip was not significantly correlated (p >.05) with any of the 5CT. Push Ups were also significantly correlated (p<.01) with Land Evacuation (r -.464), Entrenchment Dig (r= -.421), Low High Crawl (r= -.449), and Sandbag Carry (r= .459), but were not correlated with Sea Evacuation (p>.05). Finally, for the males, Sit Ups correlated (p<.01) with Land Evacuation (r -.348), Entrenchment Dig (r- =.248), Low High Crawl (r= -.348), and Sandbag Carry (r= .335). There was no statistically significant correlation between Sit Ups and Sea Evacuation (p>.05). These correlations are displayed in Figure 4.23 and 4.24.

Figure 4.23 VO2max Correlations with Sea Evacuation, Land Evacuation, and Entrenchment Dig – Males

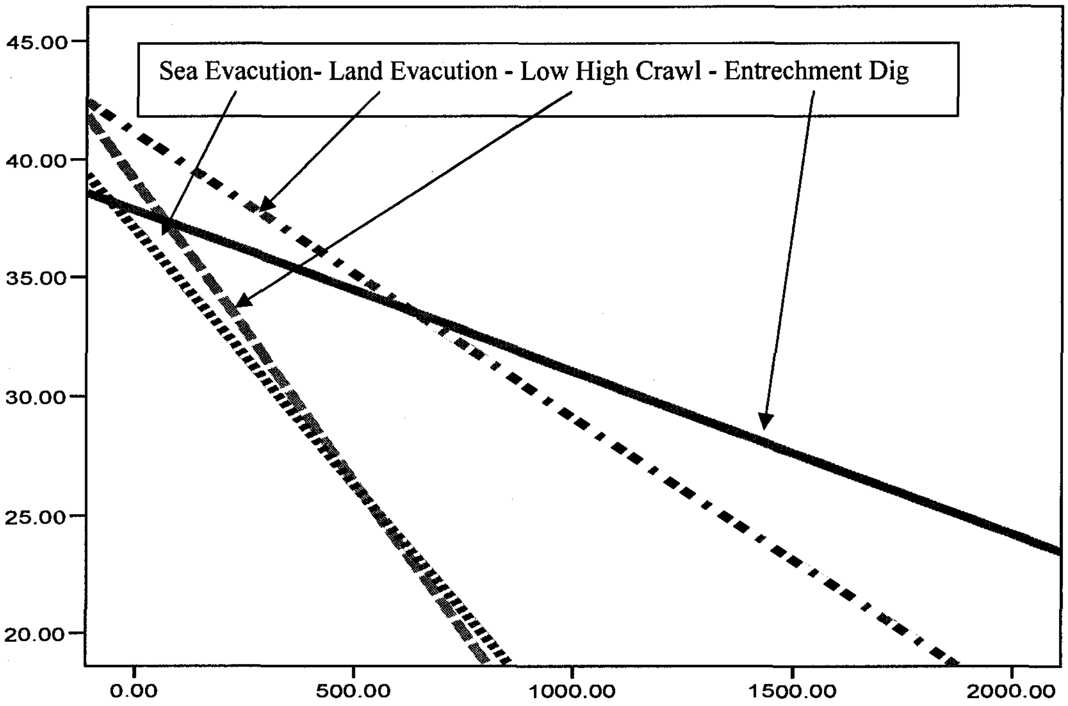


Figure 4.24. VO2max Correlations with Sandbag Carry – Males

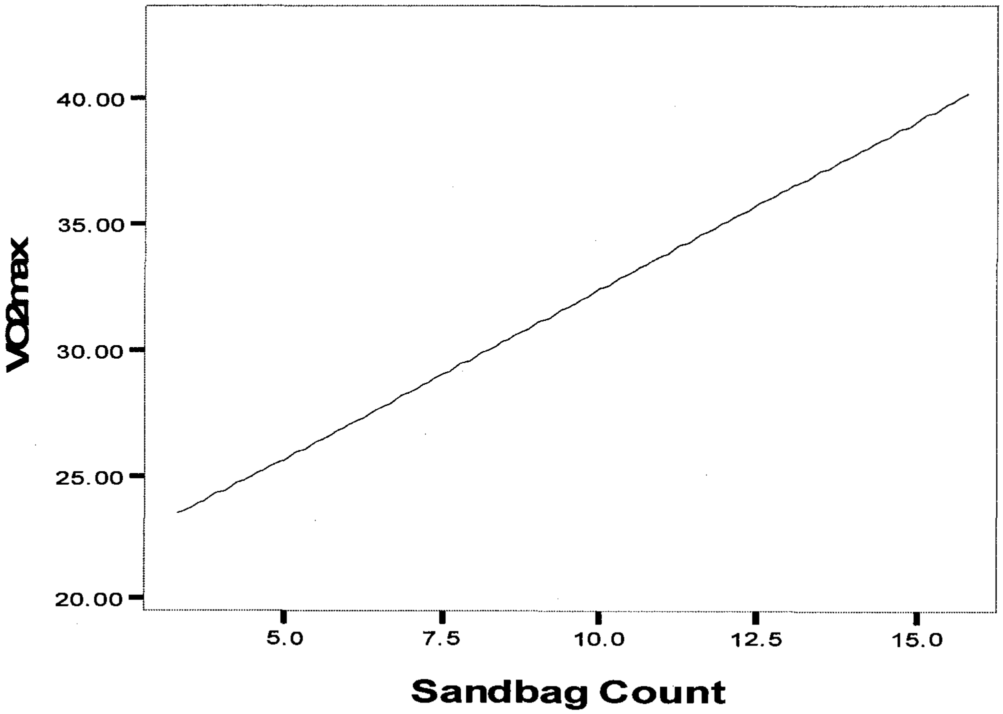


Figure 4.25 Push Ups Correlations with Land Evacuation, and Entrenchment Dig, and Low High Crawl – Males

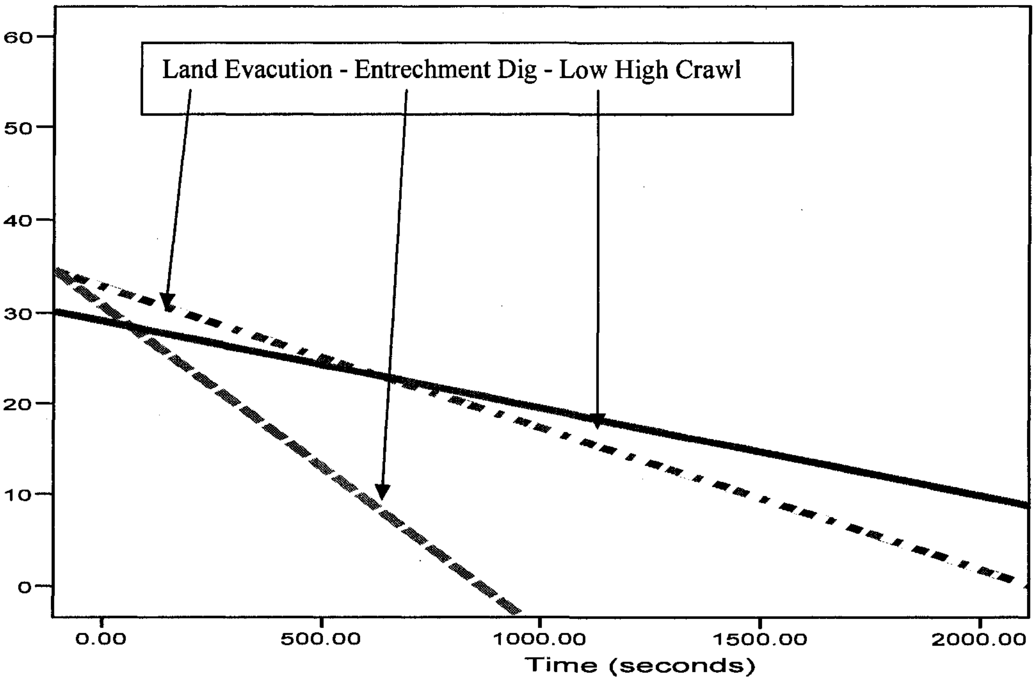


Figure 4.26 Push Ups Correlations with Sandbag Carry – Males

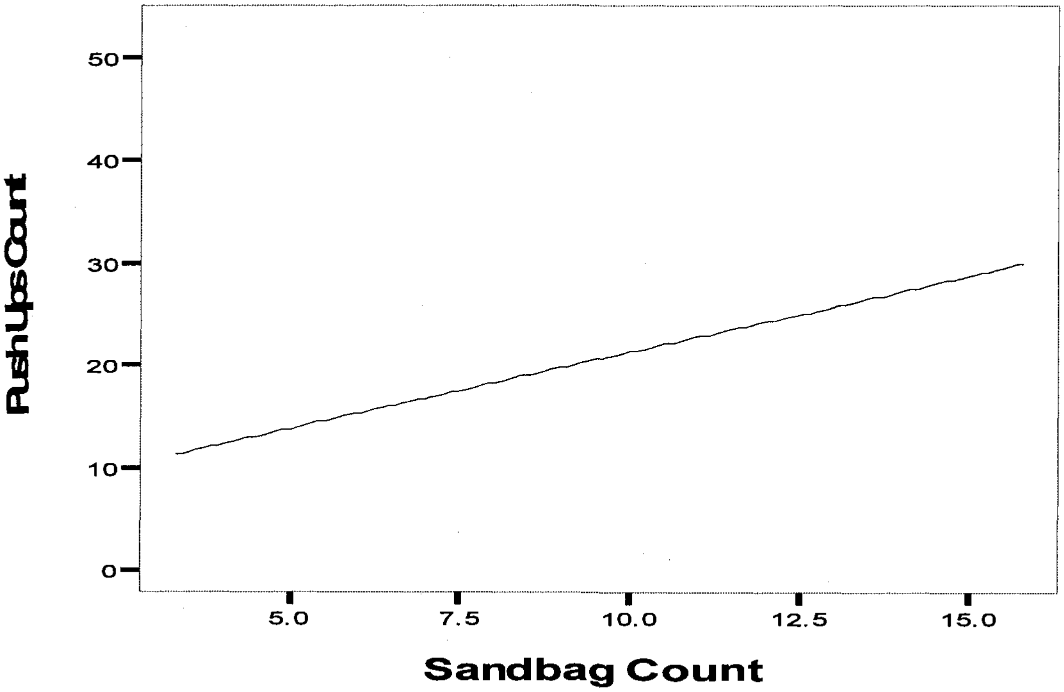


Figure 4.27 Sit Ups Correlations with Land Evacuation, Low High Crawl, and Entrenchment Dig – Males

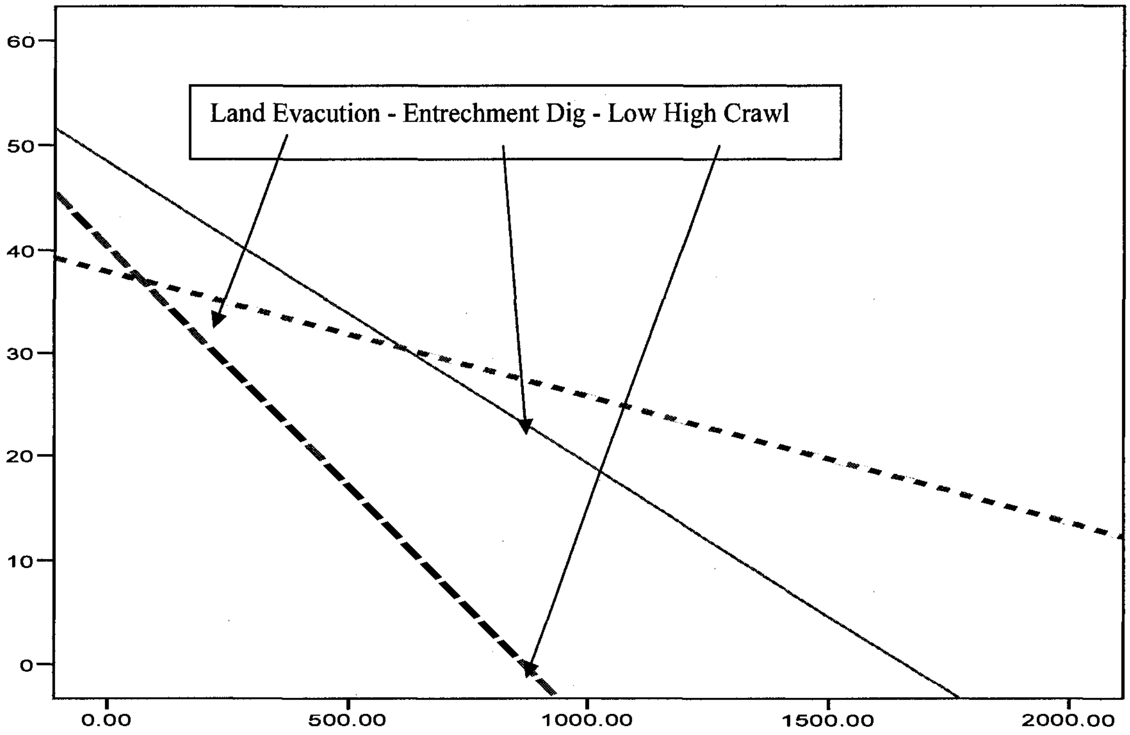
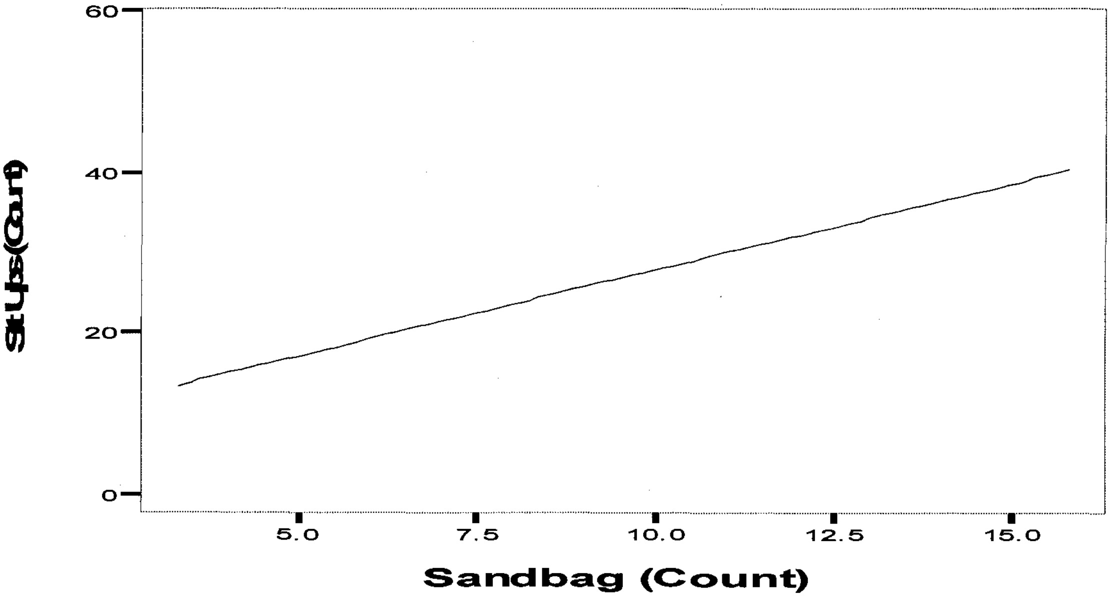


Figure 4.28 Sit Ups Correlations with Sandbag Carry – Males



For the females, Push Ups and Handgrip did not correlate with any of the 5CT. Only, Sit Ups correlated ($p < .05$) with Land Evacuation ($r = -.482$). The measurement of VO2max correlated ($p < .01$) with Land Evacuation ($r = -.715$) and approached a statistically significant correlation with the Sandbag Carry ($p = .055$, $r = .373$), the Entrenchment Dig ($p = .076$, $r = -.347$), and the Low High Crawl ($p = .052$, $r = -.385$).

Figure 4.29 VO2max Correlation with Land Evacuation – Females

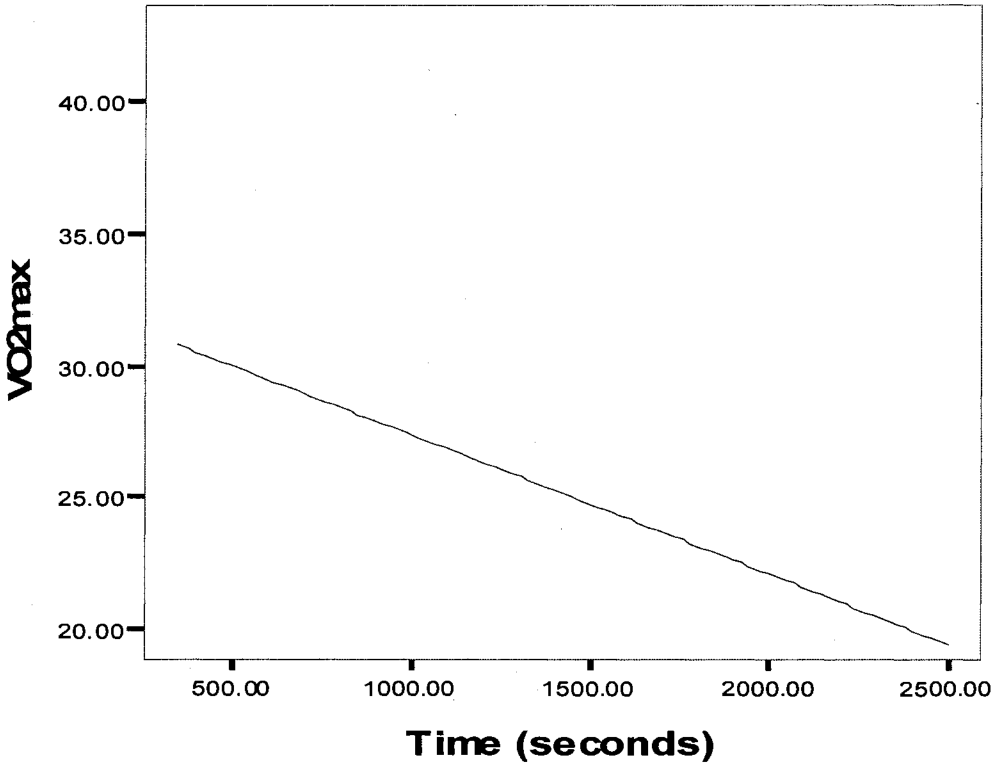
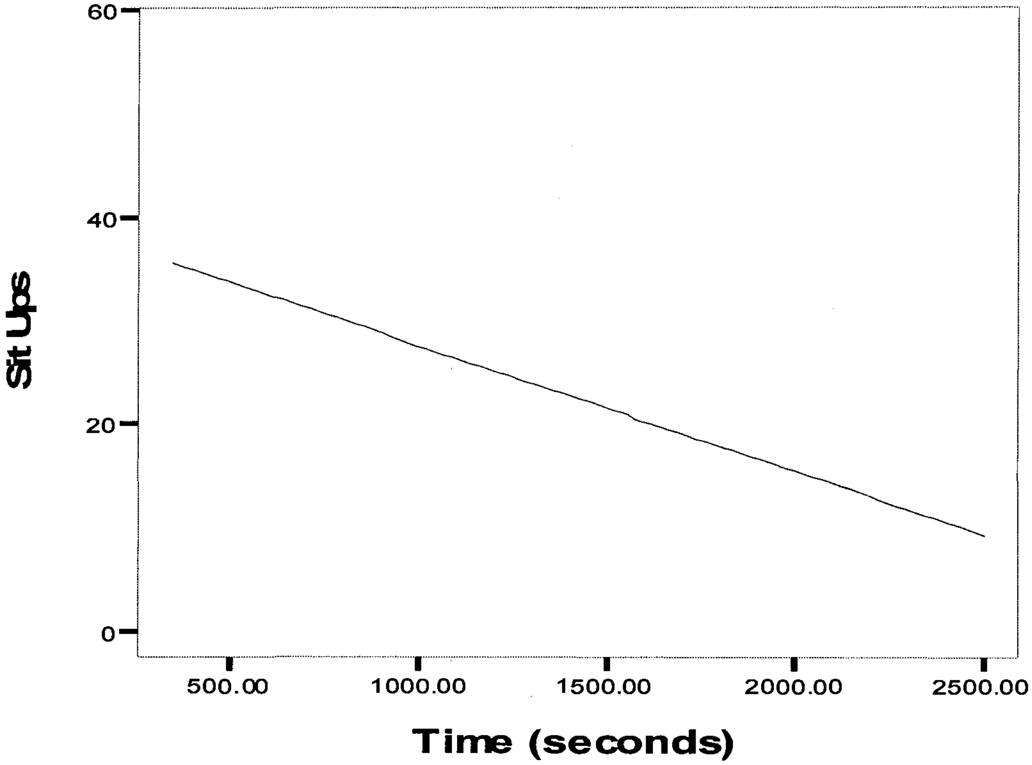


Figure 4.30 Sit Ups Correlation with Land Evacuation – Females



CHAPTER 5

DISCUSSION

5.1 Body Mass Index (BMI)

5.1.1 Descriptive Statistics

The use of BMI as an indictor for overweight status or obesity status has advantages and disadvantages and has been used to identify trends for civilian and military health status (Starky 2005; Knapik, Sharp et al. 2006) . BMI removes the dependency of weight on height by correcting bodyweight for the height of the individual (Knapik, Sharp et al. 2006). It has also been determined that the correlation between body fat and BMI is about 0.7 in civilian samples as well as in US Army recruits (Knapik, Sharp et al. 2006). However, as Knapik and collegues indicated, this indicates that only one-half of the variance in BMI is in common with body fat (Knapik, Sharp et al. 2006). This indicates that an individual may have a high BMI because of higher proportion of fat-free mass, which has a density of 1.1 g/cm^2, than fat-mass, which has a density of 0.9 g/cm^2 (W.D., F.I. et al. 1991 ; Knapik, Sharp et al. 2006). Therefore, individuals with a large muscle mass (i.e. fat-free mass) would tend to have a higher BMI (Knapik, Sharp et al. 2006).

In this study, the BMI data for males 50 to 59 years, indicated that compared to a 2004 self-reported Health and Lifestyle Information Survey for all CF members (aged 17 years and older) the percentage of CF members classified as Overweight (including Obese) were approximately the same (Directorate-of-Force-Health-Protection-CF-

Health-Services-Group 2005). However, as Table 5.1 demonstrates, in comparison to directly measured Canadian population norms, the percent of CF males aged 50 to 59 years of age classified as Overweight was 9.3% greater than in the general population.

For the female participants in this study, there was an 18.3% greater number of females aged 50 to 59 years who were classified as Overweight than in the 2004 Canadian Forces Health and Lifestyle Information Survey 2004 (self-reported survey) (Directorate-of-Force-Health-Protection-CF-Health-Services-Group 2005). However, in comparison to a 2004 Statistics Canada where BMI for females was evaluated by direct measurement of height and weight, the percent of CF females aged 50 to 59 years who were identified as Overweight was 6.9% higher than the Canadian population as a whole.

Table 5.1. Comparison of the Percentage of Individuals Classified as Overweight in CF and Canadian Studies

	Year	N	Males (%)	Females (%)
MPFS 50 Years and Older	2007	153	74.5	59.3
Jetté and Sidney	1990	19, 185	76	37
2004 CF Self-Report Survey	2004	3, 019	74	41
Canadian Community Health Survey	2004	23,985,069	65.2	52.4

(Jette and Sidney 1990; 2004; 2005)

The study also specifically identified a BMI classification of Obesity in the in 22.3% (n=35) of the CF members 50 to 59 years, which consisted of 31% of the males, and in 14.8% of the females (n=4). In contrast to Canadian norms, Obesity was identified in 23.7% of male Canadians and in 23.2% of female Canadians (2004). These data indicate that there is a greater percenta of "Overweight" CF members than the Canadian population, but that "Obesity" was approximately equal for male CF members aged 50 to

59 years to Canadian norms, but less for CF females aged 50 to 59 years than the average Canadian.

The data indicates that in this sample of CF females age 50 to 59 years of age that there was a greater percent classified as Overweight than in Canadian population norms as well as when compared to the 2004 self-survey of CF members. However, there were fewer female participants who were classified as Obese than in Canadian population norms or CF data. Unfortunately, due to the small female sample size it is not possible to determine if these differences were due to a greater proportion of muscle mass (i.e. fat-free mass) or if these differences simply occurred due to selection bias.

The study demonstrated that the that there was a greater percent of male CF members 50 to 59 years classified as Overweight than in Canadian population norms as well as when compared to the 2004 self-survey of CF members. There was also a much greater percentage of CF members who were classified as Obese. Although the higher percent of Overweight males may be partially accounted for by an increased amount of fat-free mass (i.e. muscle), it is unlikely that the high percentage of individuals classified as Obese may also be attributed to this body composition. Therefore, because increased health risk for diseases such as hypertension, type 2 disbetes mellitus, dyslipidemia, coronary artery disease, stroke, sleep apnea, osteoarthritis, gallstones, stress, incontinence, depression, and certain types of cancer are associated with an "Overweight" BMI (including Obese) and because health risk increases as BMI increases (Janssen, Katzmarzyk et al. 2002; Douketis, Paradis et al. 2005), it appears that CF members aged 50 to 59 years demonstrate a greater health risk status than the general Canadian population. It also appear that this sample of CF members are more likely to experience a diminished quality of life when compared to the general Canadian population as increasing BMI has been found to have a negative effect on physical performance and quality of life in elderly individuals (Bohannon, Brennan et al. 2005) .

5.1.2 Performance on 5CT

The comparison of 5CT performance with BMI for the whole group did not identify a correlation between BMI and the Land Evacuation, Low High Crawl, and Sandbag Carry and only a weak correlation between the Sea Evacuation and Entrenchment Dig. However, this may have resulted because of the statistically significant difference in BMI between the sexes. Thus, the evaluation of BMI correlations with performance should only be evaluated independently by sex.

For the males, it was identified that increasing BMI correlated with poorer performance time on the Land Evacuation, Low High Crawl, and Sandbag Carry, but not with the Sea Evacuation or Entrenchment Dig. In the Land Evacuation and Sandbag Carry, the Healthy/Normal BMI classification and the Overweight classification had significantly better performance (i.e. lower time or more sandbags moved) than the Obese I group, but there was no difference in performance between the “Normal” BMI and “Overweight” These data indicate that although increasing BMI correlates with poorer performance, there is not a statistically significant difference in performance between Normal/Healthy BMI and Overweight BMI on 5CT. Therefore, it is likely that many of the males classified as Overweight fell within this classification because of a higher proportion of muscle mass. It is also important to note that although increasing BMI correlated with increasing time on the Low High Crawl there was no statistically significant difference in performance time between the BMI classifications. In this task, it seems that increasing BMI, no matter what the composition (fat-free or fat-mass) does not limit the performance of the member. Finally, in the Entrenchment Dig, which is a stationary digging task, and in the Sea Evacuation, which is very short duration task, increasing BMI did not correlate with poorer performance.

The evaluation of 5CT performance and BMI for females was undoubtedly affected by the small sample size combined with individual participant's selective performance on tasks. In this sample only the improved performance on the Entrenchment Dig correlated with decreased BMI. None of the other tasks demonstrated any correlation with performance nor were there any significant differences between BMI classifications and 5CT performance. Despite the lack of statistically significant differences in performance, it is interesting to note that the Normal/Healthy BMI group did not have the best performance on any of the tasks. In the Land Evacuation, Sandbag Carry, and Low High Crawl, the Overweight group had the best performance while in the Sea Evacuation and Entrenchment Dig, the Obese I group had the best performance. Although these data cannot be viewed as conclusive, it does identify that in this group of female CF members 50 to 59 years that a BMI classified as Overweight may helped improve their performance on military tasks.

5.1.3 Performance on EXPRES

In this study, unlike Jetté and colleague' 1990 study with younger CF members (mean age for women 26.2 ± 5 years; men 32.0 ± 8 years) (Jette and Sidney 1990) where increasing BMI was related to poorer performance on all components of the

EXPRES test, the correlations between BMI and performance varied by component of the EXPRES test. Increasing BMI correlated with increasing Handgrip score and Sit-Ups score, but correlated with decreasing VO2max. In the Push-Ups test, there was no correlation with increasing BMI for the whole group. These results are unexpected, but because of the large difference in EXPRES performance the evaluation of performance by sex provided better insight.

For the males, VO2max, Push-Ups and Sit-Ups decreased as BMI increased and Handgrip did not show any correlation with BMI. When performance was compared between BMI classifications, the results were again varied. The best performance was completed by the Normal/Healthy BMI group for VO2max, Push Ups, and Sit Ups and these values were all significantly ($p < .01$) better than performance from individuals in the Obese I group. However, the differences between the Normal/Healthy BMI and Overweight BMI group were not significant. Additionally, in the Handgrip test, the Overweight BMI group had the best performance. These data indicate that performance is not significantly affected by a BMI within the Overweight classification, but that it is affected by a BMI in the Obese I classification.

Correlations for BMI and EXPRES test performance for females was very similar to the 5CT analysis. Only sit ups were negatively correlated with BMI. There were no other significant correlations or significant differences in performance between the BMI classifications. Again, this likely occurred because of an insufficient sample size.

5.2 Waist Circumference

5.2.1 Descriptive Statistics

The measurement of WC is used to measure abdominal (core) body fat and is strongly correlated with risk of health problems such as type 2 diabetes, hypertension, dyslipidemia and the metabolic syndrome (combination of all 3 of these conditions) (Douketis, Paradis et al. 2005). Additionally, WC cutoffs as identified by the NIH (i.e., ≥ 88 cm for females and ≥ 102 cm for males) may also help identify individuals within each BMI classification (i.e., Normal/Health BMI, Overweight, Obese) that have an even greater health risk (Douketis, Paradis et al. 2005). Research to-date has been limited in evaluating and presenting the WC of Canadian population norms and WC values in the CF. Additionally, because of the variety of evaluation techniques (i.e., obvious narrowing of the waist, 2 cm below the floating rib, etc.), it is difficult to compare the current study with other studies. Therefore, in the current study, only the evaluation of WC and corresponding health risk status were conducted.

In this sample of CF members 50 to 59 years of age the mean WC for the males was 96.99 cm, which is associated with the lowest health risk status (i.e. < 102 cm). However, a WC of 94 cm or greater in men has been reported to be indicative of the need for weight management in men (M.E., Han et al. 1995; Dobbelsteyn, Joffres et al. 2001) and has also be used to identify risk for cardiovascular disease (Han, van Leer et al. 1995). For the females, the mean WC was 84.5 cm, which was also associated with the lowest health risk status (i.e. < 88 cm) . However, similar to the males a WC of 80 cm or greater has nd has also be used to identify risk for cardiovascular disease (Han, van Leer et al. 1995). Thus, in this sample of CF members 50 to 59 years of age, inventions for weight control may be appropriate.

5.2.2 Performance on 5CT

It was determined that similar to BMI, increasing WC also correlated with poorer performance time on the Land Evacuation, Low High Crawl, and Sandbag Carry. Additionally, it was noted that the difference in performance time for the Low WC group was statistically better than performance in the High WC group for these same tasks. Similar to BMI, performance on the Entrenchment Dig, which is a stationary test and the Sea Evacuation, which is a short duration test do not appear to be affected by composition. For the females there were no statistically significant correlations with WC and performance and no statistically significant differences in performance between the Low or High WC groups.

5.2.3 Performance on EXPRES

In this study, the Low WC group for males had a significantly better VO2max and completed a significantly higher number of Push-Ups and Sit-Ups, but there was no difference in Handgrip. This indicates that CF members who are identified as having a lower health risk because of their WC also have increased physical fitness. For the females in this study there was no difference in physical fitness performance between the Low or High WC groups.

5.3 The Combination of BMI and WC

5.3.1 Descriptive Statistics

The combination of BMI and WC for evaluating health risk status has been identified as an effective tool for identifying health risk status. Specifically, it has been noted that even after adjusting for age, race, poverty-income ration, physical activity, smoking, and alcohol intake that people in the High WC group of any of the BMI groups (Normal/Healthy BMI, Overweight, and Obese) have an increased risk for hypertension, diabetes, dyslipidemia, and metabolic syndrome than when compared with people in the same BMI categories, but in the Low WC category.

In this study, the health risk status was determined for 126 males and 27 females. As Figure 5.1 demonstrated, 23% of the male participants in this study and 14.8% of the females were identified as having a "Very High Risk." Additionally, it is surprising to note that 33.3% of males and 25.9% of the females were classified in the High WC category, which is associated with "High Risk" and "Very High Risk." These BMI and WC classifications were than analysed to determine if performance was different between these classifications. Unfortunately, for the females, statistical analysis did not demonstrate any differences between the classifications for performance on the 5CT or EXPRES. This is likely due to the small sample size as there were noticeable differences for the males.

Figure 5.1 Using BMI and WC Measurements to Assess Risk of Health Problems

WC		Normal/Healthy 18.5–24.9 kg/m2	Overweight 25–29.9 kg/m₂	**Obese I** **30–34.9 kg/m₂**
LOW WC	Men < 102 cm	23% (n=29)	42.9% (n=54)	0.7% (n=1)
	Females < 88 cm	40.7% (n=11)	33.3% (n=9)	0
High WC	Men ≥102 cm Females ≥ 88 cm		10.3% (n=13)	
			11.1% (n=3)	

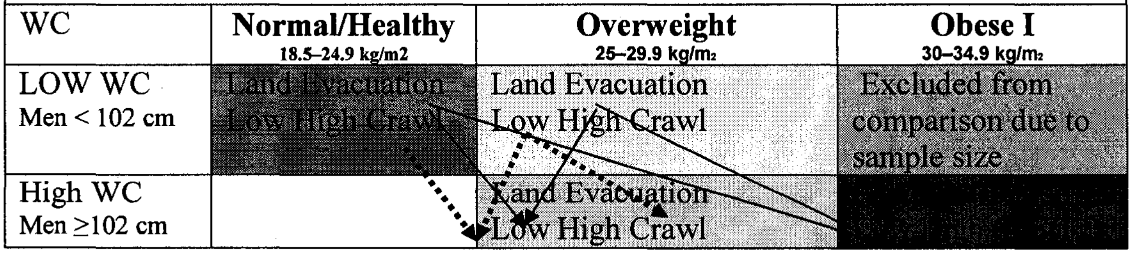
Least Risk	Increased Risk	High Risk	

(Note: Chart categories reference (Douketis, Paradis et al. 2005))

5.3.2 Performance on 5CT - Males

The evaluation of BMI and WC for males demonstrated that there was a significant difference in performance for the Land Evacuation and Low High Crawl between Least Risk Groups, Increased Risk Groups and the High Risk and Very High Risk Groups (Figure 5.4). These data demonstrate that the use of BMI and WC may provide information not only about the health risk status of the CF member, but may also provide information regarding which male CF member will be able to successfully complete military tasks.

Figure 5.2 Performance Differences in Fitness Evaluations when Combined with BMI and WC Measurements to Assess Risk of Health Problems



WC	**Normal/Healthy** **18.5–24.9 kg/m2**	**Overweight** **25–29.9 kg/m₂**	**Obese I** **30–34.9 kg/m₂**
LOW WC Men < 102 cm	Land Evacuation Low High Crawl	Land Evacuation Low High Crawl	Excluded from comparison due to sample size
High WC Men ≥102 cm		Land Evacuation Low High Crawl	

5.3.3 Performance on EXPRES – Males

In the EXPRES test there was no significant difference between BMI, WC classifications for the Handgrip score. The values for VO2max values in the "Lowest Risk" group (i.e., Normal/Healthy BMI, Low WC) were significantly different from all other risk groups. The values for VO2max in the "Increased Risk" group (i.e., Overweight, Low WC) were also statistically better than all groups in the "High Risk" and "Very High Risk" groups. However, these data do not indicate that there were significant differences in VO2max between the BMI classifications for Low WC. Although the health risk increases when someone is classified as Overweight, it is unlikely that their aerobic performance would be affected. However, there is greater concern that aerobic performance will be affected when someone is classified as Overweight, High WC and Obese I, High WC.

The Push Ups test and Sit Ups test demonstrated the same trends. These evaluations showed that individuals with the "Very High Risk" when classified by BMI and WC had the poorest performance. It was also noted that both of the High WC groups had statistically poorer performance on the Sit Ups and Push Ups tests.

5.4 The Relationship between EXPRES and 5CT

When the male participant's performance on the EXPRES test was compared to 5CT it was determined that increasing VO2max correlates with improved performance on all of the 5CT. However, the Push Ups and Sit Ups tests, which are used as tests of muscular strength and endurance, did not correlate with the Sea Evacuation. They did however correlate with all other 5CT. Handgrip also did not correlate with any 5CT for the males.

The correlations between 5CT and EXPRES performance for females were poor, but this was also likely associated with the small sample. Only VO2max and Sit Ups were significantly correlated with Land Evacuation. There were no other significant correlations.

CHAPTER 6

CONCLUSION

The participants in this study represented a broad range of military occupations, all military elements (army, air force, and navy), as well as a very broad range of ranks (i.e., from Private to Lieutenant General). Tthe participants were also recruited from all parts of Canada. However, the results from this study have several limitations. The CF members that participated in this study were not required to participate, but rather, were asked to volunteer. As a result, this sample of participants was opportunistic rather than a random sample. It is also important to note that 98.3% of the males and 100% of the females were accustomed to exerting a moderate to intense effort when they performed physical activities and 78.3% of the males and 72.0% of the females felt that that they had an above average level of physical fitness. Therefore, it is highly plausible that CF members aged 50 to 59 years of age who were less accustomed to physical activity or who were less accustomed to exerting moderate or intense effort did not volunteer for this study. Therefore, all data reported may represent a more positive view of CF member's physical abilities and body composition of CF members aged 50 to 59 years.

This study identified that when BMI and WC are evaluated separately for CF males aged 50 to 59 years that increasing BMI and WC are both independently associated with increasingly poorer performance on Land Evacuation, Low High Crawl, and Sandbag Carry and that there is a significant difference in performance for these tasks between BMI classifications and WC classifications. Additionally, it was observed that when BMI and WC are used in combination, that decreased performance is seen in the

Land Evacuation and Low High Crawl. However, in the Sea Evacuation, a test which requires powerful exertion over a short period of time, and in the Entrenchment Dig, a stationary test, increases in BMI and WC were not associated with decreased performance. In the EXPRES tes,t increasing BMI and High WC were associated with decreased VO2max and fewer Push Ups and Sit Ups. Thus, for males aged 50 to 59 years of age there appears to be some military tasks that are not affected by higher or lower BMI or WC, but that most of the components of the EXPRES test are affected by BMI or WC. It is concluded that male CF members 50 to 59 years of age who have a higher BMI or WC may be adversely affected in EXPRES test performance, but not necessarily affected in their performance of the 5CT. Therefore, the CF EXPRES test, which is designed to tet the ability to complete the occupational physical fitness test, The Five Common Tasks, may be unfairly evaluating CF members aged 50 to 59 years because of their body composition or the distribution of their body composition.

In the female participants there were no trends identified between increasing BMI or increasing WC. This is likely because of the low number of female participants. However, there were trends in for the females for improved performance in the Overweight and Obese classifications. This trend indicates that for older CF females a larger BMI may contribute to increased performance on occupational military tasks. Although in this study, there was no attempt to differentiate between fat-mass and fat-free-mass, it is likely these females were classified as "Overweight" due to increased fat-free mass.

The relationship between the components of the EXPRES test and the 5CT was also evaluated. In this population, it was determined that for males, only VO2max correlated with Sea Evacuation and that Handgrip did not correlate with any of the 5CT. This indicates that additional tests should be included in the EXPRES test as the current tests do not correlate with performance on the Sea Evacuation. These tests may include tests of flexibility (i.e. the ability to lift and lower the Sea Evacuation stretcher safely as well as perform the Low High Crawl) and power (i.e. the ability to lift the Sea Evacuation stretcher up the stairs).

In addition to the relationships of BMI, WC, and performance in the EXPRES or 5CT, the trends towards higher health risk in this population are alarming. In this population of CF members 50 to 59 years of age, it was identified that there is a 7.3% greater number of males who were classified as Obese in the CF population than compared to Canadian population norms. These data indicate that although different age ranges are being compared, that there appears to be a trend towards obesity in this male CF population. In contrast, the percentage of females who were classified as Obese was 8.4% less than the Canadian population norms.

These data indicate that although CF members aged 50 to 59 years of age may be physically capable of performing the 5CT or meeting requirements on the EXPRES test, their health risk status may prevent them from having the physiological ability to safely complete these tasks. Therefore, because 23.0% of male participants and 14.8% of female participants were classified as having a health risk status of "Very High Risk," it is recommended that BMI and WC are incorporated as a part of the CF annual physical fitness testing. Furthermore, it is recommended that annual measurements of BMI and WC are used to track changes in individual members, so that appropriate exercise training regimes can be prescribed.

CHAPTER 7

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