Exploring the Relationship between Health-Related Fitness and Biological CVD Risk Factors in Canadian Young Adult Men and Women

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By

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Abstract

Background/objectives: Established relationships exist between declining health-related fitness and Cardiovascular Disease risk (CVD) in older adults. However, the relationship between current fitness levels and CVD risk in young adults remains unclear. Current medical practices do not actively use blood lipid testing to screen for CVD in young adults however, non-optimal lipids in young adults have been associated with coronary atherosclerosis later in life. To our knowledge, no study has identified any relationship between blood lipid measures and health-related fitness levels in Canadian Young Adults for men and women. **Method:** Sixty-seven male and female Kinesiology and Nursing students (18 to 30 years of age) participated in the study. Fasting levels of HDL-C, LDL-C, Total Cholesterol (TC), Total Triglyceride, and high-sensitivity C-Reactive Protein (hs-CRP) were obtained and compared to the following health-related fitness measures: Body mass index (BMI), waist circumference (WC), the Rockport Walk Test (RWT), The YMCA Modified Sit and Reach Test, right angle push-ups, partial curl-ups, and the wall-sit. **Results:** In males, triglycerides were correlated to BMI ($r_{(27)}$=.408, p<0.05), WC ($r_{(27)}$=.541, p<0.01), and RWT ($r_{(27)}$= -.500, p<0.01). In females, TC/HDL-C ratio was correlated to WC, ($r_{(36)}$=.563, p<0.01), BMI, ($r_{(36)}$=.580, p<0.01), RWT, ($r_{(36)}$=-.496, p<0.01), push-ups, ($r_{(37)}$=-.323, p<0.05), and partial curl-ups ($r_{(37)}$=-.359, p<0.05). **Conclusion**: Our findings revealed that a relationship between health-related fitness and biological CVD risk factors does exist, but still needs to be explored in further detail. As an initial CVD screening tool for young adults, health-related fitness assessment is an attractive low-cost option that merits further investigation.

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Introduction

It is well known that physical inactivity leads to development of poor musculoskeletal health and obesity, two major modifiable risk factors for the development of Cardiovascular Disease (CVD; Eyre, Kahn, & Robertson, 2004). Unfortunately, physical inactivity is on the rise in Canada. Recent data from the Canadian Community Health Survey (Statistics Canada, 2005) suggests that 53.5 % of Canadians are physically inactive, placing them at increased risk for CVD. In Canadian adults, gender differences in physical activity levels suggest that women appear to be less physically active than men (Heart and Stroke, 2003). The CVD risk associated with physical inactivity appears more substantial when, the relative risk for Coronary Artery Disease (CAD) associated with physical inactivity is equal to that of hypertension, high blood cholesterol, and cigarette smoking (Stewart, 2005).

Physical activity is defined as “any bodily movement produced by skeletal muscles that requires energy expenditure” (WHO, 2010). Due to the variation in type, duration, intensity, and frequency that physical activity can vary, many consider it to be a behaviour that can be difficult to reliably measure (Shephard, 2003). However, physical activity directly influences physical fitness, a condition that is much simpler and more reliable to measure. Physical fitness, or being physically fit, is defined as “the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergency” (Casperson, Powell, &

Christenson, 1985, p.128). Fitness is generally divided into two categories: health-related and skill-related. In the area of CVD research, health-related fitness provides more diagnostic value than skill-related fitness, or athletic ability; the discussion will be limited to these. The five components that contribute to health-related fitness are: cardiorespiratory endurance, muscular endurance, muscular strength, body composition, and flexibility (Caspersen, Powell & Christenson, 1985). Gender differences exist in each component of health-related fitness. On average, men have larger proportions of upper body muscle mass (Heyward, Johannes-Ellis, & Romer, 1986), higher cardiorespiratory fitness (Wells, 1991), differences in joint flexibility as a result of differences in muscle and adipose tissue distribution (Alter, 2004), and carry excess body fat differently than women (Wells, 2007).

Many attempts have been made to quantify the relationship between health-related fitness and disease. Blair et al. (1995) conducted a longitudinal study into the relationship between health-related fitness and all cause mortality using self-reported activity levels, lifestyle questionnaires, and maximal treadmill exercise testing. Their research reported that men who maintained or improved their health-related fitness had lower CVD mortality rates than persistently unfit men. Similarly, research has linked sit-ups to all-cause mortality (Katzmarzyk & Craig, 2002), push-ups to incidence of diabetes (Katzmarzyk, Craig, & Gauvin, 2006), and lower back flexibility to atherosclerosis (Yamamoto et al., 2009). Studies involving gender differences, health-related fitness, and CVD are lacking and represent a gap in the research literature.

There is a substantial case to be made for early identification of individuals at medium to high-risk for CVD. Current statistics indicate that CVD is one of the leading causes of mortality in Canada, and is estimated to cost 22 billion dollars annually in direct and indirect healthcare and lost productivity costs (Statistics Canada, 2009). Current Canadian CVD screening strategies include plasma lipid profiling, which involves testing for plasma levels of the following biomarkers: triglycerides, low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), total cholesterol, and in some cases, high sensitivity C reactive protein (hs-CRP). All have been repeatedly linked to CVD (Genest et al., 2009). Current Canadian guidelines acknowledge gender differences in CVD risk assessment with recommendations that lipid profiling begin for adult men over 40 years of age, and women who are at least 50 years of age or postmenopausal. However, the presence of unfavourable lipid profiles have been recorded much sooner than this. Berenson et al. (1998) observed several CVD risk factors, including obesity, serum LDL-C, and serum triglycerides, to be significantly related to the extent of atherosclerotic lesions in children and young adults (ages 2-39). There is also emerging evidence that non-optimal lipid profiles in early adulthood are independently associated with coronary atherosclerosis two decades later (Pletcher et al., 2010).

Current Canadian blood lipid screening guidelines often identifies medium to high-risk individuals after the clinical expression of symptoms, which is usually “too little, too late” (Steinberg, Glass, & Witzum, 2008). Blood lipid results are often categorized into levels of risk using the Framingham 10 year CAD risk calculator, which uses age, gender, total cholesterol, HDL-C, smoking, and systolic blood pressure to calculate a ten-year risk score. However, even the widely used Framingham 10 year risk model has been shown to underestimate risk, especially in women and young adults (Gray, 2005). There are many possible explanations for unidentified or underestimated risk. First, some research suggests that guidelines for risk assessment are inappropriately high (Gray, 2005). Secondly, as we age, risk inevitably increases, regardless of other factors. Finally, no one is at ‘zero risk’ for CVD. Even those classified as low risk are still not guaranteed to avoid CVD. However, previous research suggests that because of the substantial effects of CVD and its symptoms, the focus of gender-specific screening strategies should be on the early identification of not only high-risk, but also medium risk individuals as well.

Recently, research has explored whether health-related fitness assessment may add any additional diagnostic value to the Framingham screening model. Mora, Redberg, Sharett, and Blumenthal (2005) found that in asymptomatic individuals, exercise capacity, exercise treadmill testing, and heart rate reserve significantly enhanced the Framingham model for both genders, especially in those with low Framingham Risk Scores. There is additional evidence that fitness assessment measures can add valuable diagnostic information and help re-stratify asymptomatic individuals in the medium risk category. In middle-aged men, abnormal exercise stress test results have been shown to advance an individuals’ risk status from medium to high, while normal test results lowered risk status (Gibbons, Mitchells, Wei, Blair, & Cooper., 2000). These studies illustrate the possibility of using measures of health-related fitness to aid in CVD screening.

Although many studies have shown direct connections between abnormal lipid profiles and the development of CVD, few have focused primarily on the relationship between lipid profiles, gender, and health-related fitness. In a meta-analysis of physical activity, fitness, and CVD mortality, all but one study used a single baseline measure of physical activity or fitness to determine future CVD risk (Kohl III, 2001). To date, there are no studies that have correlated gender specific health-related fitness assessment results that test all 5 areas of health-related fitness to biological CVD marker. Young adults may be an excellent target group for CVD screening strategies because recent research has found that non-optimal lipid levels during young adulthood (18 to 30 years of age) lead to atherosclerotic changes that persist into middle age (Pletcher et al., 2010). This study concluded, "that maintaining optimal levels of lipids throughout young adulthood can provide substantial benefits in terms of lifetime Coronary Heart Disease (CHD) prevention" (Pletcher, 2010, p.143). Similarly, Remsberg and Slervogel argue that … "CVD risk factors attained in early adulthood may represent an early warning system for future risk of developing cardiovascular disease" (2003, p. 249). This evidence indicates that monitoring and identifying medium to high-risk individuals in young adulthood could have substantial preventive effects on CVD.

Physical fitness assessment is an attractive CVD screening strategy because it is non-invasive, low in cost, requires minimal equipment, and most importantly, unlike blood lipid profiling, assessment does not require the presence of CVD symptoms before consideration. The ability to help identify young adult men and women (18 to 30 years of age) at medium to high-risk for CVD using non-invasive methods before the clinical manifestation of symptoms could prove to have very substantial changes in disease outcome.

The purpose of this study is to explore the relationship between health-related fitness and biological CVD risk factors in Canadian young adult men and women.

Review of Literature

Cardiovascular Disease

CVD is a group of conditions that affect the heart and circulatory system. Some examples of CVD include coronary heart disease (CHD), congenital heart disease, CAD, peripheral artery disease, atherosclerosis, and cerebrovascular disease (WHO, 2010). Currently, CVD is one of the leading causes of mortality in Canada and costs an estimated 22 billion dollars annually in direct and indirect healthcare and lost productivity costs (Statistics Canada, 2009). There are many known modifiable risk factors related to CVD. In Canada, it is estimated that nine out of ten individuals over the age of 20 are at increased risk for CVD based on at least one of the following risk factors: smoking, physical inactivity during leisure time, less than recommended daily consumption of fruit and vegetables, stress, poor body composition, high blood pressure, or diabetes (Statistics Canada, 2009). These risk factors do not occur equally among genders. Men are more likely to smoke, eat less than recommended daily fruit and vegetables, and have poor body composition while women are more likely to be physically inactive and have high blood pressure (Heart and Stroke, 2003). As a modifiable risk factor, physical inactivity has been shown to greatly increase CVD risk, equal to hypertension, high blood cholesterol, and smoking, (Stewart, 2005). Gender also plays it role in CVD. At younger ages, men are at much higher risk for CAD and stroke than women (Heart and Stroke, 2003).

Physical Inactivity

Physical inactivity is becoming a serious health concern in Canada. Physical activity is defined as any bodily movement produced by skeletal muscle(s) that results in energy expenditure (Caspersen et al., 1985). Recent statistics report that 53.5 % of Canadians are physically inactive, thus placing them at increased risk for CVD (Statistics Canada, 2009). In adults, gender also plays a role in physical inactivity, with women being less physically active than men (Heart and Stroke, 2003). Many studies have clearly demonstrated a link between physical inactivity and CVD mortality (Berlin & Colditz, 1990; Powell, Thompson, Caspersen, & Kendrick, 1987). Increases in physical activity have been shown to have a protective effect against the development of hypertension and obesity, two major modifiable risk factors for CVD (Blair & Brodney, 1999; Faggard, 2000). In addition to this protective effect, increases in physical activity can lead to increased serum HDL-C and decreased serum triglyceride and LDL-C, all of which are major biological (of the blood) CVD risk factors (Krauss, Winston, Fletch, & Grundy, 1998). Though not completely understood, this protective effect can be primarily attributed to improvements in body composition and cardiorespiratory fitness (Myers, 2003).

Not only is the relationship between physical activity and CVD extremely complex, physical activity itself is a very broad term that can be particularly difficult to measure. Physical activity can vary greatly in type, frequency, intensity, and duration, and thus, can be very difficult to reliably measure. In many cases, measurement tools used to quantify physical activity are highly unreliable, particularly self-report surveys (Shephard, 2003). One such survey developed by Godin and Shephard (1985) has been shown to have intra-class correlation coefficients as low as 0.46. In addition to the problems of measurement, poor memory recall can result in a 50% variation in questionnaire responses after an interval of only a few days (Kriska, 2000). Finally, due to the lack of consensus of energy requirements that define light, moderate, and vigorous physical activity, studies have revealed that international definitions are required if issues of reliability are to be resolved (Caspersen, Merritt, & Stephens, 1994; Gordis, 1979).

Physical activity is a behaviour that is difficult to reliably measure. However, how physically active an individual is directly influences his/her physical fitness, a condition that is much easier to quantify. Physical fitness is defined as "A set of attributes that people have or achieve relating to their ability to perform physical activity" (U.S. Department of Health and Services, 1996). Physical fitness can be divided into two categories: skill related and health related. For the purposes of public health, skill related fitness, or athletic ability, provides little diagnostic information and will not be the focus of this study.

Health-Related Fitness

The health related components of physical fitness are: body composition, muscular endurance, muscular strength, cardiorespiratory fitness, and flexibility (Casperson et al., 1985). Many studies have shown a strong, positive correlation between health-related physical fitness and physical activity (Blair, 1985; Ekelund et al., 1988). To date, no known study has individually correlated each health-related component of fitness to biological CVD risk factors.

Body composition. Body Mass Index (BMI) is defined by the World Health Organization (2004) as "a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults"(p. 1). BMI is calculated as weight in kilograms divided by the square of the height in meters (kg/m^2)". Body fat, or adiposity, has been repeatedly associated with CVD (Bonara, 2006). In fact, the American Heart Association reports "weight gain during young adult life may be one of the most important determinants of cardiovascular risk factors" (Krauss et al., 1998). Current WHO guidelines stipulate BMIs less than 18.5, 18.5 to 24.9, 25 to 29.9 and greater than 30 are categorized as underweight, normal, overweight, and obese respectively. Obesity, as defined by the WHO, is a known modifiable independent risk factor for the development of CVD (Bonora, 2006). A meta-analysis of 57 prospective studies conducted by Whitlock et al. (2009) found BMI to be a strong predictor of overall mortality both above and below the healthy range of 22.5 to 25 kg/m^2. Recent research has shown excess adipose tissue in the abdominal region further increases CVD risk (NIH, 1998). Waist circumference (WC) is a measure of abdominal obesity and has been repeatedly shown to be a strong risk factor for CVD, independent of BMI and other risk factors (Koning, Merchant, Pogue, & Sonia, 2006; NIH, 1998; WHO, 2004). Abdominal obesity is defined by the National Institutes of Health (NIH) in women as 88 cm or more and 102 cm or greater for men (1998). When used together, WC and BMI help to identify those at increased CVD risk within the normal-weight, overweight, and class I obese BMI categories (Janssen, Katzmarzyk, & Ross, 2002).

Muscular strength and endurance. Muscular strength is defined as a muscle or muscle groups' ability to generate muscular force again a resistance, one time (Casperson et al., 1985). A familiar measure of strength is the 1-rep maximum, or the maximum amount of weight a muscle or group of muscles can move. Performing a 1-rep maximum requires specialized skill that places a great deal of stress on muscles, tissues, and bones, and increases the risk of injury significantly (Brzycki, 1993). A more common measure of assessing the musculoskeletal system is to incorporate measures that involve both muscular strength and muscular endurance. Muscular endurance is defined as a muscle or muscle groups' ability to generate sub-maximal force repeatedly over time (Casperson et al., 1985).

Many studies have suggested that muscular strength and endurance is inversely related to all cause and CVD mortality (Blair et al., 1989; Myers et al., 2002). In 2002, Katzmarzyk and Craig report a relationship between muscular strength and endurance and prediction of early death. Their research found sit-ups, a simple measure of abdominal muscular strength and endurance, to be predictive of mortality in Canadian adults aged 20 to 69, independent of BMI and WC. Specifically, the results showed a significantly higher relative risk of mortality in the lowest quartile of sit-ups in both men (2.72, 95% CI 1.56-4.64) and women (RR = 2.26, 95% CI 1.15-4.43) (Katzmarzyk and Craig, 2002). Similar research between physical fitness and diabetes found upper body muscular strength and endurance, measured by a simple push-up test, to be significantly related to the incidence of diabetes in Canadian adults (Katzmarzyk et al., 2006). The study found that after adjusting for age and gender, push-ups were associated with significantly lower odds ratio (0.47) of developing diabetes. Currently there are no studies that have explored the possibility of using upper, core, or lower muscular strength and endurance measures to aid in CVD risk assessment.

Cardiorespiratory fitness. Cardiorespiratory fitness is a measure of an individuals' circulatory and respiratory systems' ability to provide oxygen to working muscles, most often reported as the amount of oxygen per kilogram of body mass that an individual can consume (ml/kg/min; Casperson et al., 1985). Cardiorespiratory fitness is commonly measured in the lab by graded exercise testing and in the field using the Rockport Walk Test (RWT). The correlation between the RWT and treadmill max VO_2 scores has been shown to be high, $r=.88$, $p<0.01$ (Colcombe et al., 2003). Poor cardiorespiratory fitness has been established as an independent risk factor for all-cause and CVD mortality (Blair et al., 1989; Ross & Katzmarzyk, 2003). Low cardiorespiratory fitness is also a strong predictor of mortality, comparable to high cholesterol, hypertension, and cigarette smoking (Wei et al., 1999). Similar research by Blair et al. (1996) encourages physicians to promote sedentary individuals with low cardiorespiratory fitness to become more physically active to reduce risk of premature mortality associated with CVD. Their research suggests that cardiorespiratory endurance effectively lowers CVD risk, and many studies have reported similar findings. Carnethon et al. (2003) reports that in young adults, increasing cardiorespiratory fitness effectively lowers CVD risk. Similarly, Dunn et al. (1999) revealed that a physical activity intervention in adult males and females was effective at improving cardiorespiratory fitness and blood pressure, thus modifying CVD risk. The relationship between CVD risk and cardiorespiratory fitness appears strongest in obese individuals, where increased cardiorespiratory fitness has been reported to display a protective effect on CVD risk (Barlow, Kohl III, Gibbons, & Blair, 1995; Lee, Blair, & Jackson, 1999). Despite the strong connection between cardiorespiratory fitness and CVD, it is still unclear whether the association is causal or merely predictive.

Flexibility. Flexibility is defined as "the absolute range of motion in a joint or series of joints that is attainable through momentary effort or with the aid of a partner or machine" (Gummerson, 1990, p. 96). There is emerging evidence that flexibility may play a diagnostic role in CVD screening. Recently, Yamamoto et al. (2009) found abdominal and trunk flexibility to be an independent risk factor for CVD. The study reported that in middle and old age participants, brachial ankle pulse wave velocity was significantly higher in middle-aged and older subjects with poor flexibility versus middle and older subjects with high flexibility (Yammamoto et al., 2009). The study associated poor trunk flexibility with arterial stiffening in middle and old age adults and concluded that it should be considered a CVD risk factor, independent of other measures of fitness. In young adults, the relationship was less clear. To date, this is the only known study that links flexibility and CVD.

Gender Differences in Health-Related Fitness

When assessing health-related fitness, it is important to recognize that males and females have different physiological characteristics, and thus, should be treated as different groups. Beginning with muscular strength and endurance, previous research has established that in general, men have a greater number and size of muscles fibers than woman, and that these differences are mostly, but not exclusively found in the upper body (Heyward, Johannes-Ellis, & Romer, 1986; Levine, Falkel, & Sawka, 1984). In regards to aerobic capacity, women show several physiological differences that lead to a lower oxygen carrying capacity and VO2 when compared to men. These differences include less blood volume, lower cardiac output, smaller hearts, fewer red blood cells and less hemoglobin (Wells, 1991). Adult males and females also differ greatly in body composition. Males generally haves a greater total lean mass, mineral mass, and a lower fat mass (Wells, 2007) and as a result, display significant differences in tissue distribution than females. Adult males have larger and stronger bones, reduced limb fat and greater arm muscle mass, however male and female central adiposity is similar, though there are differences in overall adipose distribution (Wells, 2007). Overall adipose distribution in females during early adulthood is more peripheral. Lastly, gender differences also occur in flexibility, particularly at the pelvic region, where women's hips are broader and shallower, allowing for a greater range of motion then men (Alter, 2004). Differences in muscle mass, fat distribution, and joint geometry between males and females are also thought to contribute to flexibility differences.

Biological CVD Risk Factors

There is a substantial case to be made for early identification of individuals at not only high, but also medium risk for CVD. Current Canadian CVD screening strategies include plasma lipid profiling, which involves testing for serum levels of the following biological markers associated with CVD: triglycerides, LDL-C, HDL-C, total cholesterol, and in some cases, hs-CRP. Each has been repeatedly linked to CVD (Genest et al., 2009). Current clinical Canadian guidelines recommend beginning lipid profiling in adult men over 40 years of age, and women who are at least 50 years of age or postmenopausal (Genest et al., 2009).

Serum triglycerides. Triglycerides are lipids that circulate in the blood stream and are ultimately stored and used as energy between meals (NIH, 2002). When found in excess, predominantly due to a caloric imbalance, triglycerides may contribute to the hardening and thickening of the arterial wall and ultimately atherosclerosis and CVD. Whether triglycerides are causal or indicative of CVD is still unclear. However, a meta-analysis of 17 population-based prospective studies involving over 50 000 adults by Hokanson and Austin (1996) found triglycerides to be a strong independent risk factor for CVD in both men and women. In young adults, Pletcher et al. (2010) report that serum triglycerides levels above 1.70 mmol/L can be indicative of atherosclerosis two decades later. Current Canadian blood lipid guidelines stipulate that fasting triglyceride levels above 1.70 mmol /L place an individual in the high-risk category for CVD (Genest et al., 2009).

Low density lipoprotein cholesterol. LDL-C is produced by the liver and circulates throughout the blood stream to deliver cholesterol to tissues and organs (NIH, 2002). LDL-C that is not used by tissues continues to circulate throughout the blood stream and eventually oxidizes and clings to the arterial wall, contributing to the development of atherosclerosis (NIH, 2002). LDL-C makes up about 60-70% of total serum cholesterol and because of its known atherogenic properties, is the primary focus of CVD prevention strategies (NIH, 2002). Many population-based studies have found a direct relationship between LDL cholesterol and future CVD events in men and women (Lipid Research Clinics Program, 1984, 1985; Stamler, Wentworth, & Neaton, 1986). The relationship holds true even in those individuals already diagnosed with CVD (Pekkanen et al., 1990; Rossouw, Lewis, & Rifkind, 1990). Increased physical activity has been shown to significantly decrease serum LDL-C. A meta-analysis of 95 studies revealed that physical activitys effect on serum LDL-C is primarily mediated by weight loss (Tran & Weltman, 1985). Current Canadian Lipid Guidelines state that fasting LDL-C levels greater than 3.5 mmol/L are associated with an increased risk for developing atherosclerosis and CVD (Genest et al., 2009). However, recent research suggests that levels much lower than current Canadian guidelines are associated with CVD risk. Research involving 3258 young adults (18-30 years of age) by Pletcher et al. (2010) reports that LDL-C levels above 2.59 mmol/L can be indicative of atherosclerosis two decades later.

High density lipoprotein cholesterol. HDL-C is produced by the liver and circulates throughout the blood stream to deliver excess serum cholesterol from the cells of the arterial wall back to the liver for elimination through the gastrointestinal tract in a process called reverse cholesterol transport (Toth, 2003). HDL-C comprises approximately 20 to 30% of total serum cholesterol (NIH, 2002). In general, individuals with high HDL-C have a greater capacity to remove excess cholesterol and prevent atherosclerosis than those with lower HDL-C levels (Toth, 2003). Many studies associate decreased HDL-C levels to be significantly related to the development of CVD in adults (Wilson et al., 1998, Cooney et al., 2009; Toth, 2003; Pletcher et al., 2009). The precise mechanisms associated with HDL-C production are unclear, but some studies suggest physical activity may play a major role (Despres,Lemieux, Dagenais, Cantin, & Lamarche, 2000; Rubins et al., 1999). Current Canadian guidelines state that HDL-C levels below 1.0 mmol/L are classified as high CVD risk (Genest et al., 2009). Recently, Pletcher et al. (2010) found that in young adults, levels below 1.55 mmol/L are associated with significantly greater risk for atherosclerosis two decades later.

Total serum cholesterol. Total cholesterol is simply the sum of HDL-C, LDL-C, and other lipoproteins. In a 25-year follow up study involving seven different countries, total cholesterol was linearly related to CHD mortality (Vershcuren et al., 1995). Similar research by Pekkanen et al. (1990) found total cholesterol levels to be a significant predictor of mortality from CVD in men aged 40 to 69. In general, the more cholesterol you have, regardless of the type, the greater your risk for CVD. Canadian Lipid Guidelines state that levels above 5.0 mmol/L are associated with increased CVD risk (Genest et al., 2009).

Unidentified CVD Risk

Collectively, these biological markers are strong predictors of CVD. Yet, despite these powerful connections to CVD, there remains some unexplained variability in CVD risk unaccounted for by a traditional blood lipid profile. There are many possible explanations for unidentified risk. There is some evidence that HDL-C serum levels do not always accurately represent HDL-C function. Van Lenten et al. (1995) showed that during the acute phase response (the bodys response to trauma or injury), HDL-C loses its ability to inhibit LDL-C oxidation. In this scenario, change in HDL-C function occurred without any change in serum HDL-C levels, and thus a blood lipid panel may not accurately reflect true CVD risk.

High-sensitivity C-Reactive Protein (hs-CRP). Recent research has focused on the predictive power of hs-CRP in addition to a traditional blood panel. Hs-CRP is an acute phase protein produced by the liver in response to inflammation or infection (Ridker, 2000). There is strong evidence that implicates chronic inflammation in the development of CVD (Ridker, 2000; Ross, 1999). In men, elevated levels (>1 mg/L) of serum hs-CRP are associated with 2-fold increase in risk for stroke, a 3-fold increase in risk of myocardial infarction, and a 4-fold increase in developing peripheral vascular disease (Ridker, Cushman, Stampfer, Tracy, & Hennekens

1997, 1998). Similarly, many studies have shown elevated levels of hs-CRP to be a strong independent risk factor for CVD in women (Ridker, Buring, Shih, Matias, & Hennekens,1998). Research into hs-CRP and CVD screening by Danesh et al. (2000) suggest that hs-CRP may account for some of the unexplained variability in CVD risk not recognized by a traditional blood profile. This hypothesis is confirmed by Ridker (2003), who observed individuals with LDL-C levels below 3.36 mmol/L but with hs-CRP levels greater than 3 mg/L to represent a high-risk group often missed in preliminary clinical testing. Finally, a meta-analysis of all published studies on hs-CRP prior to 2000 revealed that subjects with values in the upper third (>2.4 mg/l) compared to the lower third (<0.9 mg/l) had a 2.0 fold increase risk for future coronary events (Danesh et al., 2000).

Despite the range, sensitivity, and speed at which hs-CRP levels can change as a result of the acute phase response, Hutchinson et al. (2000) have demonstrated hs-CRP levels to be stable in the general population. The addition of hs-CRP to a traditional blood panel has also been shown to improve CVD risk assessment in both men and women (Ridker, Hennekens, Buring, & Rifai, 2000). Based on this emerging evidence, new Canadian guidelines recommend the inclusion of hs-CRP to blood lipid testing to help inform treatment decisions (Heart and Stroke Foundation, 2009).

Gender and Age Differences in Biological CVD Risk Factors

Gender and age differences are important factors when examining biological CVD risk factors. Women tend to have higher triglycerides and HDL-C when compared to men (Shaw et al., 2006). Though women generally have higher HDL-C, gender differences tend to disappear with age, leveling out during menopause (AHA, 2004). Men tend to have higher TC until age 50, at which point women have higher values (Shaw et al., 2006). It is generally accepted that men have greater baseline risk than women until the fifth decade (Shaw et al., 2006). Women are also reported to have higher baseline levels of hs-CRP (Shaw et al., 2006).

Gender and Age Differences in CVD Risk Assessment. Gender differences in biological CVD risk factors have shaped CVD risk assessment. Current Canadian cholesterol guidelines (Genest et al., 2009) assesses CVD risk using the Framingham Model, which calculates short-term risk based on gender, age, total cholesterol, HDL-C, systolic blood pressure, and smoking. Framinghamn classifies risk into three categories, low, intermediate, and high, which equates to less than 10%, 10-20%, and a greater than 20% chance of suffering a heart attack or CHD (Genest et al., 2009). However, the Canadian Cardiovascular Society suggests caution as the Framingham model has been shown to underestimate risk in women and young adults (Genest et al., 2009). Specifically, CVD risk assessment in young women and men is a complex issue as most young adults will have very low short-term risk (ten-year) but may in fact be at high lifetime risk (AHA, 2004). This is primarily attributed to age, which is a dominant factor in the Framingham CVD risk analysis (Genest et al., 2009). In this respect, women and young adults are at a significant disadvantage when using the Framingham Model to calculate CVD risk.

Evidence Supporting Fitness Based CVD Risk Assessment

Previous research suggests that because of the substantial effects of CVD and its symptoms, the focus of primary screening strategies should be the identification of medium to high-risk individuals as early as possible. Recently, research has explored whether exercise testing may add any additional diagnostic value to CVD screening methods. In asymptomatic individuals, Mora et al. (2005) used exercise capacity, exercise treadmill testing, and heart rate reserve to further enhance risk stratification in the Framingham Model. Specifically, they were able to reclassify approximately 50% of male and females in the medium risk category, as high-risk. In addition, half of the female participants classified as low risk based on the Framingham Model were reclassified as high-risk. In this study, the prognostic value of heart rate reserve and low exercise capacity significantly enhanced the Framingham model for both genders. Similarly, in middle aged men, Gibbons et al. (2000) observed abnormal aerobic stress test results to advance an individual's risk status from medium to high, while normal test results lowered risk status. These studies illustrate the possibility of using measures of health-related fitness to help screen for CVD.

Physically active individuals have been observed to have more favourable lipid profiles than those who are physically inactive (Fletcher et al., 1996). This suggests that increased baseline measures of health-related fitness would correlate to a more favourable lipid profile. There is evidence to support this theory. Many common field measures of physical fitness have been correlated to hs-CRP. Taafe, Harris, Ferrucci, Rowe, and Seeman (2000) revealed baseline measures of hs-CRP to be associated with walking measures and grip strength in adults aged 70 to 79. Similarly, the English Longitudinal study of ageing involving 1,926 men and 2,260 women (aged 65.3 +/- 9.0 years) reports an inverse relationship between hs-CRP and grip strength that appears to be more robust in women (Hammer & Molloy, 2009). In a sample of 205 children and young adults, a significant inverse relationship between aerobic fitness and hs-CRP was observed (Carmen et al., 2003). To date, there are no known studies that focus strictly on the relationship between hs-CRP, gender, and each of the five components of health-related fitness.

Like hs-CRP, there is similar research linking fasting levels of LDL-C, HDL-C, and triglycerides to physical fitness levels (Katzmarzyk, Malina, & Bouchard, 1999). Research into physical fitness and HDL-C levels by Leclerc, Allard, Talbot, Gauvin, and Bouchard (1985) found HDL to be strongly correlated to the number of sit-ups performed in one minute. In adults, HRR has been shown to be associated with triglyceride to HDL-C ratio (Shishehbor, Hoogwerf, & Lauer, 2004). Similar research has revealed an inverse relationship between HDL-C and physical activity in adults (Ellison et al., 2004; Wilsgaard & Arnesan, 2004). In general, research has shown that higher health-related fitness levels are associated with more favorable lipid profiles.

Despite the abundance of research involving physical activity, physical fitness, gender, and biological CVD risk factors, the relationship still remains unclear. Many studies have reported that the relationship between physical fitness and CVD is largely mediated by adiposity (Boreham et al., 2001; Carnethon et al., 2003). However, this relationship is very complex and not yet fully understood. In 2003, Duncan reported that regardless of adiposity, increasing cardiorespiratory fitness might have a protective effect that modifies CVD risk. Age also plays an important role in CVD risk assessment, particularly in young adults whose physical fitness levels have been shown to steadily decline (Caspersen, Pereira, & Curran, 2000).

Which Age Population to Target?

As mentioned previously, as we age, CVD risk increases regardless of other factors (Remsberg & Slervogel, 2003), suggesting a proactive approach to CVD risk assessment is preferable if disease prevention is to be achieved. Recently, Pletcher et al. (2010) correlated baseline measures of HDL-C and LDL-C in young adulthood to be significantly related to coronary atherosclerosis two decades later. Furthermore, Remsberg and Slervogel argue that … "CVD risk factors attained in early adulthood may represent an early warning system for future risk of developing cardiovascular disease" (2003, p. 249). These studies indicate that monitoring and identifying medium to high-risk individuals in young adulthood could have substantial preventive effects. Currently, there are no known CVD screening strategies that target young adults.

Although many studies have shown direct connections between poor lipid profiles and the development of CVD, few have focused specifically on the relationship between lipid profiles and the five components of health related fitness in Canadian Young men and women. In a meta-analysis of physical activity, fitness, and CVD mortality, it was reported that all but one study used a single baseline measure of physical activity or fitness to determine future CVD or CHD risk (Kohl III, 2005). It is unclear how the five areas of health-related fitness collectively relate to CVD risk. To date, no studies have correlated a health related fitness assessment battery that tests all five components of physical fitness with biological CVD risk factors in young adult men and women. Physical fitness assessment is an attractive CVD screening strategy because it is non-invasive, low in cost, requires minimal equipment, and most importantly, unlike blood lipid profiling, assessment does not require the presence of CVD symptoms before consideration. The ability to help identify young adult men and women at medium to high-risk for CVD using non-invasive methods ten, possibly twenty years before the clinical manifestation of symptoms could prove to have very substantial changes in disease outcome.

Purpose

The purpose of this study is to explore the relationship between health-related fitness and biological CVD risk factors in Canadian young adult men and women.

Hypothesis

Young adult men and women with poor cardiorespiratory fitness, body composition, muscular strength, muscular endurance, and flexibility will be more likely to have non-optimal levels in at least one of the biological CVD risk markers; when compared to participants with higher levels of fitness. Women will have lower baseline physical fitness and higher HDL-C and hs-CRP levels than men.

Rationale

The significance of this research is to explore a CVD screening method that targets younger adults. If the use of a simple, non-invasive fitness test can help identify individuals at medium to high-risk for CVD twenty, possible thirty years before traditional screening methods, it would help close the gap between disease management and disease prevention. Knowledge of individual risk in early adulthood could potentially have a huge impact on disease outcome by providing the opportunity to modify several major CVD risk factors before it becomes too little, too late. In addition, as a tool for prevention, fitness assessment could be an inexpensive and non-invasive addition to any CVD screening strategy that targets younger adults.

Method

Participants

Participants for this project were obtained in two ways. The majority of data were obtained from students in a required first year Principles of Health Kinesiology (Kine 1113) class at Lakehead University. Prior to assessment, all Kine 1113 students provided consent to the release of all personal information collected through class work for use in future research projects (Appendix A). Approximately 120 Kine 1113 students completed a health-related fitness assessment battery as was required for successful completion of an assignment within the course. Following the health-related fitness assessment, all Kine 1113 students were provided the option to have their blood tested for biological CVD risk factors. In total, 66 Kine 1113 students elected this option. All Kine 1113 classroom data was used retrospectively. In total, 64 out of 66 Kine 1113 student data were used. Two Kine 1113 students' data were excluded due to inability to meet blood lipid analysis fasting criteria. Additionally, three participants were recruited from a first year Introduction to Nursing Class. Nursing student recruits provided written consent prior to participating in the study. (Appendix A). In total, 28 male and 39 female Lakehead University students between the ages of 18 to 30 years were included in the analysis.

Instrumentation

In total, seven tests were used to measure the five areas of health-related fitness and six tests were used to measure biological CVD risk factors. Fitness tests were chosen because of their minimal time and equipment requirements, as well as their links to the biological CVD risk factors used in this study. The health-related fitness assessment battery used was partially modeled after the Presidents Challenge Adult Fitness Test (2011), an industry standard in health-related fitness assessment. Body composition was measured using two tests: BMI and WC. BMI was measured using WHO (2002) guidelines and is a standard measure used to classify body weight in adults. Weight was measured using a digital scale measured to one decimal place. Height was measured using a wall-mounted stadiometer. WC was measured using NIH (1998) guidelines using a standard measuring tape and recorded to the nearest centimetre. Cardiorespiratory fitness was measured using the Rockport Walk Test, a one-mile indoor walking test used to estimate maximal oxygen consumption (VO_2 max). Time for this test was measured using a digital stopwatch. Heart rate was measured using Polar ™ Heart Monitors. Flexibility was measured using the Modified YMCA Sit and Reach Test, which measures trunk flexion in the seated position. Trunk flexion was measured using a standard measuring tape.

Muscular strength and muscular endurance were measured using a combination of three measures that tested upper, core, and lower body muscular strength and endurance. Upper body muscular strength and endurance was measured using the ACSM 90-degree push-up test, which requires no equipment. Core muscular strength and endurance was measured using the ACSM partial curl-up test, which is timed to one minute. Lower body muscular strength and endurance was measured using the wall-sit test, a timed to completion test. Time for both tests was measured using a digital stopwatch. All tests were monitored for correct form by an assessor and self-reported by the participant.

Demographic and exclusion criteria data were collected using Health Physical Activity Participation Questionnaire (HPAPQ), the Physical Activity Readiness Questionnaire (Par-Q), and the Fantastic Lifestyle Checklist (FLC). All three surveys are endorsed by the Canadian Society on Exercise Physiology (CSEP; 2010) as prescreening tools to enhance safety. The PAR-Q is a mandatory CSEP (2010) prescreening tool that allows professionals to determine whether or not it is in the best interest of the client to consult a physician before participating in physical activity or fitness appraisals. The HPAPQ and FLC are both recommended by CSEP (2010) as additional prescreening options for gathering health and CVD risk information about clients.

Lastly, biological CVD risk factors were measured using blood lipid analysis conducted by LifeLabs Medical Services in Thunder Bay, Ontario. Blood collection was conducted by certified Phlebotomists and results were calculated using the ADVIA Chemistry Systems assay Kits.

Pilot Project

A pilot project was conducted prior to the commencement of the research study to test the effectiveness of the assessment protocol to safely and reliably assess health-related fitness in a timely fashion. In total, 16 participants (10 females, 6 males) were assessed using a variation of the final study protocol. No injuries were reported, and the total time required to complete the health-related fitness assessment battery of tests was approximately one hour. Chair-squats were used as a measure of muscular strength and endurance during the pilot project. Results indicated a ceiling effect with chair squats thus leading to the decision to consider using wall-sits as an alternative for this measure. There is currently no known reliability or validity studies on the wall-sit, and as such, a study was undertaken to assess the reliability of the wall-sit protocol. The wall-sit test-retest reliability study was conducted with testing occurring 7 days apart, with assessments occurring during the same time of day for both sessions. In total, 76 participants were used and results found reliability for the wall-sit protocol to be high, $r = .812$, $p<0.01$. As a result, wall-sits replaced chair-squats for the health-related fitness assessment protocol.

Procedure

The current research project was approved by the Research Ethics Board at Lakehead Univeristy. Specifically, ethical approval was granted after the completion of Kine 1113, but prior to Nursing student data collection. All participants were initially screened using the PAR-Q (Appendix B), a standard safety protocol for individuals thinking about becoming more physically active. Kine 1113 students completed the PAR-Q as part of course requirements. Nursing students were required to complete the PAR-Q prior to inclusion in the study.

All exclusion information was gathered using the Fantastic Lifestyle Checklist (FLC), the Healthy Physical Activity Readiness Questionnaire (HPAPQ), and the PAR-Q (Appendix B). Kine 1113 students completed the HPAPQ and FLC as part of course requirements. Kine 1113 student data were only used if all eligibility criteria were met. No Kine 1113 student data were excluded based on the FLC, HPAPQ, or the Par-Q. Nursing student participation required the completion of the HPAPQ and FLC prior to inclusion in the study. Both health-related fitness assessment and blood lipid analysis are negatively affected by the following conditions:

smoking, acute illness, recent surgery, recent traumatic injury, and the presence of cholesterol reducing medications. Recent surgery, recent traumatic injury, acute illness, and smoking are all conditions that have a negative impact on physical health and thus, negatively effect health-related fitness. Smoking and cholesterol reducing medications both effect blood lipid levels. The final exclusion criteria was failure to complete the required 12-hour fast and/or 48 hour fast from alcohol required for blood lipid analysis. Two Kine 1113 students failed to successfully complete a 12 hour fast or a 48 hour fast from alcohol, and were removed from the study. Finally, the order of testing was the same for all participants. As mentioned previously, Kine 1113 students completed the health-related fitness assessment assignment first, and were provided the course option of blood lipid analysis second. For all participants, health-related fitness assessment and blood lipid analysis occurred on separate days so the potential effects of the 12-hour fast that blood lipid analysis requires did not affect the outcome of the physical health and fitness assessments. Kine 1113 health-related fitness assessments were conducted in groups of approximately 15 to 20 students. Nursing student health-related fitness assessments were conducted individually. All health-related fitness assessments were conducted at the CJ Sanders Fieldhouse at Lakehead University. Participants were asked to wait a minimum of 72 hours after fitness assessment before undergoing blood lipid analysis. All participants were asked to abstain from vigorous physical activity 24 hours prior to fitness assessment and blood collection. Blood lipid analysis results were forwarded to a local Cardiologist in Thunder Bay. If any individual was found to have abnormal results, the cardiologist requested that he/she be invited to be retested in the near future.

Testing Protocol

The testing for this study was conducted in two stages: the first being health-related fitness assessment, the second blood lipid analysis. The procedures for both are described below.

A team of assessors conducted the physical health and fitness assessments. All assessments were conducted in the Fieldhouse and the Hangar at Lakehead University. All assessors were Kinesiology students who were trained and monitored by individuals with an Honours degree in Kinesiology. Prior to testing, all assessors were provided with and required to review a written assessment protocol (Appendix C) that outlines the assessment procedures. All tests were administered in the same order, as follows: 1) Body Composition Measures (BMI and WC), 2) Cardiorespiratory Fitness Measure (Rockport Walk Test), 3) Flexibility Measure (YMCA Modified Sit and Reach Test), and 4) Muscular Strength and Endurance Measures (90 degree push-ups, partial curl-ups, wall-sits). Participants were allowed time between tests to recover (a maximum of 10 minutes), with overall assessment requiring approximately 50 minutes to complete.

Assessment of body composition. Measures of body composition were taken in the CJ Sanders Building at Lakehead University, in the exercise physiology lab (SB 1027). Body mass index was calculated from weight measured on a digital scale, and height measured using a wall-mounted stadiometer. Results were compared to WHO (2004) guidelines and categorized accordingly (Appendix D). Waist circumference was measured just above the iliac crest according to NIH guidelines (Appendix C). Following measures of body composition, all participants were equipped with Polar Heart Rate monitors and then instructed to proceed to the Hangar for the remainder of testing.

Assessment of cardiorespiratory fitness. The Rockport Walk Test (Appendix C) is an indoor 1-mile walk test that uses heart rate, time, and gender to estimate VO_2 max. The Rockport Walk Test was originally validated by Kline et al. (1987) and has been cross validated in many studies (Coleman et al., 1987; Ward et al., 1987; Zwiren, Freedson, Ward, Wilkie, & Rippe, 1991). Reliability coefficients have been reported between 0.91 and 0.97 (Dolgener et al., 1994; Kline et al., 1987). All participants were familiarized with testing procedures prior to assessment. The assessment was conducted at the Hangar at Lakehead University on a pre-measured indoor-track (8 laps to a mile). Each participant performed a one-lap warm-up followed by light dynamic stretching. Heart rate was measured electronically using a Polar heart rate monitor. Time was recorded using two digital timers. An assessor recorded time and heart rate immediately after completion of the test. The main outcome measures were total walk time (minutes), heart rate (beats per minutes), and estimated VO_2 Max (kg/ml/min). Estimated VO_2 Max was calculated using the Rockport Walk Test Equation and reported in kg/ml/min.

Assessment of flexibility. Trunk flexibility was assessed using the YMCA Modified Sit and Reach protocol (Appendix C), which is a measure of trunk flexion while in the seated position. Previous studies have reported reliability estimates to be consistently high, ranging from 0.96 to 0.99 (Jackson & Baker, 1986; Jackson & Langford, 1989; Shaulis, Golding, & Tandy, 1994). Trunk flexibility was assessed in the cardio room located adjacent to the indoor track in the Hangar at Lakehead University. Participants were instructed to remove any footwear and assume a seated position on the floor with knees extended, feet roughly 12 inches apart. The heel of the foot will be placed on the 38-cm mark. Participants were instructed to place one hand on top of the other and lean forward as far as they can in a slow, controlled manner, exhaling and lowering the chin as they do so. Legs must be kept straight during the test. Measures were taken from the point of the middle digit at furthest reach using a ruler or pointer. The assessment was conducted twice, with the average of both scores reported in cm.

Assessment of muscular strength and endurance measures. Muscular strength and endurance was assessed in the cardio room located adjacent to the indoor track in the Hangar at Lakehead University. The order of muscular strength and endurance measures was as follows: upper body, core, and lower body.

Upper body muscular strength and endurance was assessed using the ACSM 7th Edition right angle pushup test (Appendix C), which involves the participant performing as many pushups in a row as possible until failure or proper form can no longer be maintained. Reliability coefficients for the 90-degree push-up have been reported as high as .86 (McManis, Baumgartner, & Wuest, 2000). This test has the participant start in the resting or front leaning position with hands approximately shoulder width apart, elbows in close to the abdomen, and feet together. The arms, back, buttocks and legs must be straight from head to heels and must remain so throughout the push-up. Shoes may or may not be worn. Participants begin the push-up by lowering the entire body until the top of the upper arms, shoulders, and lower back are aligned and are parallel to the floor, with elbows flexed at 90-degrees. Next the participant was instructed to return to the resting position by extending the elbows until the arms are straight. Women performed a modified version of this test, which has the starting position from the knees. Repetitions were counted and recorded by an assessor. The main outcome measure was reported as the maximum number of repetitions performed until failure.

Core muscular strength and endurance was assessed using ACSM 7^{th} Edition partial curl-up test (Appendix C). Test-retest reliability has been shown to be very high (r = 0.98; Diener, Golding, & Diener, 1995). During this test, the participant assumes a supine position on a mat with the low back and shoulders flat against the floor and the knees bent at a 90-degree angle. Arms are placed on top of legs, palms facing down. The participant is instructed to tighten the abdominal muscles and flatten his/her back against the floor. Next, the chin is tucked into the chest and with the hands resting on the legs, the upper body will be curled forward until the shoulders come off the floor and the hands touch the kneecaps. The participant is instructed to return to the starting position once hands touch kneecaps. Repetitions were counted and recorded by the assessor. The main outcome measure was the maximum number successful repetitions in 60 seconds.

To assess lower body muscular strength and endurance, the 90-degree wall-sit test was used (Appendix C). The 90-degree wall-sit is a popular test used in rehabilitation (Cook, Burton, & Fields, 1999; Higgins & Perrin, 1997) and strength training (Johnson & Roppe, 1999) studies. Reliability and validity studies involving the 90-degree wall squat are limited and represent a major gap in the literature. Two known reliability statistics (r = .85, p<0.01 and r = .812, p<0.01) have been reported in unpublished works by McIntosh and Affleck (1995), and Paterson, Larocque, and Thompson (2010) respectively.

The test begins with the participant standing with his/her back against the wall. The participant assumes the sliding position by sliding down the wall until his/her thighs are parallel to the floor and a right angle is made at the knees and hips. Once this position is reached, timing begins and the participant is asked to hold the position for as long as possible, keeping hands crossed against the chest at all times. Test is terminated when participant fails to maintain position. The main outcome measure is recorded in seconds.

Assessment of Biological CVD Risk Factors

Following fitness assessment, participants were provided with a blood lipid analysis referral form and asked to report to one of three LifeLabs collection centres in Thunder Bay for blood collection. All blood specimens were drawn by LifeLabs Services, a company that is certified in all aspects of blood collection. Following health-related fitness assessment, participants were instructed to wait at least 72 hours before undergoing blood lipid analysis, as increased physical fitness can skew blood lipid analysis results. Prior to blood lipid analysis, all participants were instructed to undergo a 12-hour food fast and a 24-hour fast from alcohol. In addition, all participants were required to abstain from vigorous exercise 24 hours prior to blood collection. Blood lipid analysis requires that three ml of blood will be drawn and tested for serum lipids and lipoproteins and five ml of blood will be drawn to measure hs-CRP. Serum lipids, inflammatory markers, and lipoproteins were measured in fresh serum samples using the following ADVIA Chemistry Systems assay Kits for: Cholesterol, High Sensitivity C-Reactive

Protein, Direct HDL Cholesterol, Direct LDL Cholesterol, and Triglycerides. All Assays measure to within .01 mmol/L. Two weeks after completion of health-related fitness assessments, a follow-up was conducted on individuals who had not completed the blood lipid analysis and after four weeks, participants were deemed to have dropped out of the study and be excluded from the final analysis. The main biological outcome measures were: LDL-C, HDL-C, Total Cholesterol, TC/HDL-C, Total Triglycerides, and hs-CRP. Blood lipid analysis results were classified using two different CVD risk assessment systems: Current Canadian Cardiovascular Society Guidelines (2010), and the National Cholesterol Education Program Guidelines (NCEP; 2009). This was done to highlight potential areas of interest in CVD risk assessment in Canadian young adults.

Data Analysis

Descriptive statistics were used to examine and describe sample demographics. Specifically, means and standard deviations were used to group and categorize HPAPQ and FLC scores, as well as health-related fitness and biological CVD risk factor results. To examine the relationship between each health-related fitness measure and each biological CVD measure, Pearson Correlation's Coefficient analysis was used. Pearson Correlation Analysis is a measure of correlation that describes the linear dependence between two variables.

Results

All 67 participants completed the health-related fitness assessment and blood lipid analysis. In the final analysis, one female measure of aerobic capacity was not included due to a faulty heart rate monitor, and another female's baseline body composition measures were excluded from the analysis (at the request of the participant). In addition, two wall-sit assessments and one partial curl-up test were deemed incomplete and excluded from the final analysis. There were no reported injuries, and no tests had to be interrupted for health and safety reasons.

Sample Demographics

Demographic information for the sample was collected in two ways. The HPAPQ was used to measure lifestyle behaviours during the past 30 days. The FLC was used to measure health benefits associated with current levels of physical activity. Mean BMI and WC classified the sample as having normal or low CVD risk, with one standard deviation in BMI placing some participants as overweight. Mean HPAPQ scores for males and females indicate they are receiving excellent health benefits from current levels of weekly physical activity. Mean FLC scores indicate that most participants have engaged in healthy lifestyle behaviours in the past 30 days that reduce CVD risk. Together these findings indicate that the sample population consists of physically active non-smoking young adults who engage in healthy lifestyle practices that reduce CVD risk. Table 1 provides demographic information of the sample.

Table 1
Male and Female Demographic Results

	Age (years)	BMI (kg/m^2)	WC (cm)	HPAPQ Score	FLC Score
Male (N)	28	28	28	28	28
Mean	19.64	24.57	83.97	9.36	75.00
SD	2.25	3.04	8.15	1.85	8.44
Female (N)	39	38	38	39	39
Mean	19.64	23.75	82.02	8.92	73.10
SD	2.21	4.87	12.60	1.91	14.31

Note 1. HPAPQ scores health benefits of current physical activity levels and classifies them as follows: 0 = Needs Improvement, 1-3 = Fair, 4-5 = Good, 6-8 = Very Good, 9-11 = Excellent
Note 2. FLC scores an individuals lifestyle habits during the previous 30 days and classifies them as follows: 0-34 = needs improvement, 35-54= Fair, 55-69 = Good, 70-84 = Very Good, 85-100= Excellent

Health-Related Fitness Assessment Results

Beginning with body composition, as reported in Table 1, mean body composition results for both males and females were healthy. BMI for males and females was classified as normal, while mean WC measures suggested low CVD risk associated with abdominal obesity. Together these results indicate the sample has low CVD risk associated with obesity.

All remaining health-related fitness results (except wall-sits) were classified using normative data from ACSMs 7^{th} Edition guidelines (Heywood, 1998). Mean $V0_2$ for both males and females was classified as excellent and suggests that cardiorespiratory fitness in the sample was high. In males, mean push-up and partial-curl-up results were classified as fair and excellent respectively, indicating upper body and core muscular and endurance was at or above average. In females, mean push-up and partial curl-up results were just below average. Trunk flexibility results for both males and females were classified as needs improvement. Males significantly outperformed females in estimated VO_2 ($t(64) = -7.80$, $p<0.01$), push-ups ($t(65) = -4.85$, $p<0.01$), and partial curl-ups ($t(64)=-.209$, $p<0.05$). Table 2 displays health-related fitness assessments results grouped by gender.

Table 2
Male and Female Health-Related Fitness Assessment Results

	Estimated VO_2 (ml/kg/min)	Sit And Reach Result (cm)	90^0 Push-ups	Partial Curl-ups	Wall-Sits (sec)
Male (N)	28	28	28	27	28
Mean	53.68	6.49	31.12	39.74	134.57
SD	5.37	10.92	9.43	12.76	71.31
Female (N)	38	39	39	39	37
Mean	45.53	7.21	19.87	33.38	107.59
SD	5.89	9.71	9.41	11.67	54.08

Note 1. For men, mean estimated $V0^2$, partial curl-ups, and 90^o push-ups results were classified as fair or excellent and mean sit and reach results as needs improvement using ACSMs 7th Ed. normative data.
Note 2. For women, mean estimated $V0^2$ was classified as excellent while mean partial curl-ups, 90^o push-ups, and sit and reach results were borderline needs improvement/fair according to ACSMs 7th Ed. normative data.
Note 3. Wall-sits do not have any known validated normative data.

Biological CVD Risk Factors Results

Biological CVD risk factor findings reflect previously reported research by Pletcher et al. (2010). Specifically, the high percentage of participants (83.5%) with one or more non-optimal lipids (classified using National Cholesterol Education Program Guidelines, 2009) is nearly identical to figures reported by Pletcher et al. (2010). Blood lipid analysis also revealed a high percentage of participants with two or more non-optimal lipids. The most common pairing of non-optimal lipids was non-optimal LDL-C and non-optimal HDL-C. In males, all participants with non-optimal LDL-C (21.4% of males) also had non-optimal HDL-C. In females, 10 (25.64%) had non-optimal LDL-C and HDL-C. According to the Canadian Guidelines, which uses Framingham 10 year CAD Risk Calculator, all participants are classified as having low risk (<10%). In low risk patients, current Canadian Cardiovascular Society Guidelines (2009) indicate that before any treatment or intervention strategy is implemented, one of the following two criteria must be met: LDL-C > 5.0 mmol/l , or TC/HDL-C > 6.0 mmol/l. All of the participants in this study were classified as low risk with levels below those listed above and thus, would not be candidates for treatment and intervention. However, research by Pletcher et al. (2010) suggests that in young adults, non-optimal LDL-C (greater than 2.59 mmol/L) is significantly related to the development of coronary atherosclerosis two decades later. In our study, 83% of participants were classified as having at least one non-optimal lipid and according to Pletcher et al. (2010), may be at greater risk for developing coronary atherosclerosis later in life (45+ years of age).

When comparing groups, females had significantly higher total cholesterol ($t(65) = 3.09$, $p<0.01$), HDL-C ($t(65) = 3.359$, $p<0.01$), and hs-CRP ($t(65) = 2.77$, $p<0.01$). Tables 3 and 4 provide descriptive data of male and female blood lipid analysis results.

Table 3
Male and Female Blood Lipid Analysis Results

	TC (mmol/l)	LDL-C (mmol/l)	HDL-C (mmol/l)	TC/HDL (mmol/l)	Triglyc. (mmol/l)	Hs-CRP (mmol/l)
Male (N)	28	28	28	28	28	28
Mean	3.95	2.26	1.27	3.19	.97	1.03
SD	.71	.62	.29	.59	.35	2.23
Female (N)	39	39	39	39	39	39
Mean	4.53	2.48	1.57	3.00	1.05	2.73
SD	.79	.52	.41	.71	.46	2.64

Table 4
Percentage of Non-Optimal Lipids in Males, Females, and Overall

	Optimal LDL-C (<2.59 mmol/L)	Non-Optimal LDL-C (>2.59 mmol/L)	Optimal HDL-C (>1.55 mmol/L)	Non-Optimal HDL-C (<1.55 mmol/L)	At least 1 Non-optimal Lipids	2 or more Non-Optimal Lipids
Overall (N)	41	25	21	46	56	17
(%)	(62.7%)	(37.3%)	(31.4%)	(68.6%)	(83.6%)	(25.4%)
Male (N)	21	6	2	26	26	6
(%)	(78.6%)	(21.4%)	(7.1%)	(92.9%)	(92.9%)	(21.4%)
Female (N)	20	19	19	20	30	11
(%)	(51.3%)	(48.7%)	(48.7%)	(51.3%)	(76.9%)	(28.2%)

Note 1. Non optimal is defined by the NCEP as the following: LDL-C > 2.59 mmol/L, HDL-C < 1.55mmol/L, or Triglycerides >1.77 mmol/L.

Pearson Correlations for Health-Related and Biological CVD Risk Factors

Pearson correlations were performed to assess the degree of association between the biological markers – HDL-C, LDL-C, total cholesterol, TC/HDL-C, triglycerides, and hs-CRP – and the health-related fitness measures- body mass index, waist circumference, estimated VO_2 Max, trunk flexibility, number of right angle push-ups, number of partial curl-ups, and time maintaining a 90 degree wall-sit.

Three associations of interest were observed for the male data. First, a weak inverse relationship between total push-ups and the ratio of total cholesterol to HDL-C ($r(65) = -.323$, $p<0.01$) was observed, which to our knowledge, has not been previously reported in the literature. Second, a moderate inverse relationship between VO_2 and triglycerides ($r(65)= -.50$, $p<0.01$), was observed in men, which reflects findings reported by Berlin and Colditz (1990). Finally, in men, measures of body composition were not associated with LDL-C or HDL-C, both major predictors of future CVD risk. This does not reflect established relationships in previously reported research involving middle-aged and older populations (WHO, 2004; NIH, 1998). Table 5 displays Pearson Correlations for health-related and biological CVD measures in males.

Table 5
Pearson Correlations for Health-Related and Biological CVD Measures in Males

	Age	WC	BMI	VO_2 Max	Sit and Reach	90^0 Pushup	Sit-ups	Wall-Sit
TC	.267	.047	.048	-.007	-.373	.004	.054	.016
LDL-C	.300	.051	.066	-.033	-.409*	-.127	-.020	.065
HDL-C	-.045	-.239	-.239	.174	-.092	.297	.198	-.003
TC/HDL-C	.316	.304	.306	-.192	-.221	-.323*	-.060	-.033
Tri	.354	.541**	.408*	-.500**	.134	-.130	-.155	-.304
Hs-CRP	-.108	-.216	-.117	-.002	.005	-.025	.281	.023

Note 1. * = p<0.05, **= p<0.01

Pearson correlations were also tabulated between the biological markers – HDL-C, LDL-C, total cholesterol, TC/HDL-C, triglycerides, and hs-CRP- and the health related fitness measures- body mass index, waist circumference, estimated VO_2 Max, trunk flexibility, number of right angle push-ups, number of partial curl-ups, and time maintain a 90 degree wall-sit for women. For women, health-related fitness measures appeared more associated with biological CVD risk factors than in men. Beginning with body composition measures, BMI was moderately associated with LDL-C, ($r(36) = .463$, $p<0.01$), (hs-CRP, $r(36) = .593$, $p<0.01$), and the ratio of total cholesterol to HDL-C, ($r(37) = .563$, $p<0.01$). Similarly, WC was moderately associated with TC/HDL-C, ($r(36) = .563$, $p<0.01$), and hs-CRP, ($r(36) = .411$, $p<0.05$). WC was also weakly associated with LDL-C, ($r(36) = .330$, $p<0.05$). These findings reflect previously reported research (WHO, 2004; NIH, 1998). Possible explanations for these findings in women but not men could be a larger standard deviation in BMI measures when compared to men (4.87 kg/m^2 vs 3.04 kg/m^2), and a larger sample size. These results are presented in Table 6.

Table 6
Pearson Correlations for Health-Related And Biological CVD Measures in Women

	Age	WC	BMI	VO_2 Max	Sit and Reach	90^0 Pushup	Sit-ups	Wall-Sit
TC	.025	.171	.308	-.067	-.108	.019	-.058	-.080
LDL-C	.018	.330*	.463**	-.234	-.044	-.083	-.151	-.051
HDL-C	.036	-.170	-.127	.270	-.175	.208	.132	.003
Ratio	.193	.563**	.580**	-.496**	.076	-.323*	-.359*	-.073
Trigly.	-.016	.146	.246	-.201	.050	-.130	-.105	.094
Hs-Crp	-.046	.411*	.593**	-.266	.043	-.025	-.099	-.131

Note 1. * = $p<0.05$, **= $p<0.01$

The greatest number of associations between the health-related fitness measures and biological measures involved TC/HDL-C. Significant relationships were observed between TC/HDL-C and five of the seven health-related fitness measures – BMI, WC, VO_2, total push-ups and partial curl-ups. The clinical value of the ratio of total cholesterol to HDL-C in women is currently under investigation but does show promise as a clinical measure of future CVD risk. Research by Ridker, Rifai, Cook, Bradwin, and Buring (2005) focusing on the clinical value of frequently used lipid measures indicates that TC/HDL-C may be a better predictor of future coronary events in women than more frequently used measures of LDL-C, HDL-C, and hs-CRP. Our results indicate that women with lower levels of health-related fitness and increased BMI and WC were associated with an increased ratio of total cholesterol to HDL-C, highlighting a potential avenue for future research to explore.

Discussion

The primary goal of this study was to explore the relationship between a each component of health-related fitness and biological CVD risk factors in Canadian young men and women, and the study revealed a number of issues that need to be investigated further. The data revealed two alarming trends that are a cause for concern. First, the prevalence of non-optimal lipids reported supports previous findings by Pletcher et al. (2010). Eighty-three point five percent of participants had one or more non-optimal lipids but unlike Pletcher, the sample was homogenously physically active and by self report, engaging in healthy lifestyle practices that lower CVD risk. With the predicted rise of CVD mortality in the coming years, largely linked to rising rates of obesity and diabetes (WHO, 2004; NIH, 1998), the prevalence of non-optimal lipids in apparently healthy young adults is a cause for concern and should be investigated further.

Second, in men, measures of body composition were not associated with LDL-C or HDL-C, both major predictors of future CVD risk. This does not reflect established relationships in previously reported research involving older populations (WHO, 2004; NIH, 1998). The lack of relationships between measures of body composition and lipids in our sample is a cause for concern as many CVD risk assessments and guidelines are partly based on BMI and WC measures. These findings could indicate that measures of BMI and WC are inadequate at providing accurate, preliminary CVD risk assessment in healthy young Canadian men. However, it is important to note that while body comp measures were not significantly associated with

HDL-C or LDL-c, both measures of body composition were significantly related to triglycerides, which is reflective of past research.

In contrast, our results did suggest that the relationship between health-related fitness assessment and biological CVD risk factors in Canadian young men and women may be an important area of research to explore. Two relationships of interest were observed in the male data results. A weak (r=.25-.50) inverse relationship between total push-ups and the ratio of total cholesterol to HDL-C was also observed which has to our knowledge, not been previously reported in the literature. Second, a moderate inverse relationship between estimated aerobic capacity and triglycerides was observed in men, which reflects findings reported by Berlin and Colditz (1990). Promoting physical activity through health-related fitness assessment is important because elevated serum triglycerides are primarily caused by being overweight or obese, and being physically inactive. Also, promoting physical activity through health-related fitness assessment can positively modify these risk factors and thus, help lower serum triglyceride levels. Both relationships could be used to infer future CVD risk in Canadian young adults, but more research with larger and more heterogeneous samples is needed to explore these relationships in greater detail.

In women, health-related fitness measures appeared to be more associated with biological CVD risk factors than in men. BMI was moderately associated with LDL-C, hs-CRP, and the ratio of total cholesterol to HDL-C while WC was weakly associated with LDL-C. These findings reflect previously reported research (WHO, 2004; NIH, 1998). Moderate positive relationships were also observed between BMI, WC and the ratio of total to HDL-C. Similarly, moderate negative relationships were observed between the health-related fitness measures – estimated aerobic capacity, total push-ups and partial curl-ups – and the ratio of total to HDL-C cholesterol. The clinical value of the ratio of total cholesterol to HDL-C in women is currently under investigation but does show promise as a clinical measure of future CVD risk. Research by Ridker, Rifai, Cook, Bradwin, and Buring (2005) focusing on the clinical value of frequently used lipid measures indicates that the ratio of total cholesterol to HDL-C may be a better predictor of future coronary events in women than more frequently used measures of LDL-C, HDL-C, and hs-CRP. In this study, biological CVD markers were more closely associated with health-related fitness measures in women than in men. Specifically, women with lower levels of health-related fitness and increased BMI and WC were associated with an increased ratio of total cholesterol to HDL-C, highlighting a potential avenue for future research to explore. Our findings suggest that in healthy young Canadian adult women, health-related fitness measures could be used to gain insight into future CVD risk.

It is important to discuss the implications of using both NCEP and Canadian Cardiovascular Society Guidelines in this study. According to Canadian Cardiovascular Society Guidelines, no participants in this study were candidates for intervention or treatment, which can primarily be attributed to age. However, if we use NCEP guidelines combined with recent evidence presented by Pletcher et al. (2010), 83% of participants may be at increased long-term risk for developing CAD. A major difference between NCEP and Canadian guidelines is that Canadian Guidelines uses the Framingham Model to assess CVD risk, which is short-term (ten years) and thus, has been recognized to under-estimate true CVD risk. The evidence presented by Pletcher et al. (2010) demonstrates that short-term CVD risk assessment may not be accurately reflect true risk in young adult men and women. Though this study has its limitations, the ability to use health-related fitness as a tool for both assessment and prevention of CVD in young adults is an attractive, low-cost option that merits further research.

Of equal importance is the implication of the sample demographics of this study population. According to Par-Q, FLC, HPAPQ, and health-related fitness results, our sample appears to be physically active and engaging in healthy lifestyle practices that lower CVD risk. However, the biological CVD risk factor results suggest otherwise. According to Pletcher et al. (2010), 83.6 % of participants may be at increased long term risk for developing atherosclerosis. These findings are a cause for concern as the prevalence of non-optimal lipids in our study were found in a population that most would consider homogenously healthy and physically active. If an inverse relationship does exist between health-related fitness and biological CVD markers in young adult men and women, then these results would suggest that physically inactive individuals engaging in less favourable lifestyle habits would be at even greater long term risk for developing atherosclerosis.

Finally, this study has several strengths that warrant discussion. One major strength of this study is that the assessment measures are very common, low-cost tests used to quantify health-related fitness. In addition to low-cost, past research has shown strong connections between each health-related fitness measure used in this study and CVD risk. Similarly, there is an abundance of evidence that suggests because of the substantial effects of exposure to CVD and its symptoms, identifying young-adults at increased risk for CVD earlier will allow for very substantial changes in disease outcome. Thus, there is merit to exploring the feasibility and validity of using simple measures of health-related fitness to screen and aid in prevention of CVD in young adult men and women. To date, there is no known young adult specific screening system in existence.

Conclusion

The goal of this research study was to explore the relationship between health-related fitness and biological CVD risk factors in Canadian young men and women. Our findings have revealed that a relationship between the two does exist, but it is still unclear if this relationship can be used to help infer current or future CVD risk. As an initial CVD screening tool, health-related fitness assessment is an attractive option that merits further investigation. It is low in cost, requires little time, equipment, and man-power, and could provide early identification of individuals at increased risk for CVD, thus affecting substantial changes in disease outcome. As a tool to change health status, health-related fitness assessment can put the ability to monitor and modify CVD risk directly into the hands of the patient. With the upcoming predicted rise in CVD mortality rates, it is clear that research into CVD screening strategies should focus on identifying risk as early as possible. In this study, the overwhelming majority of our sample population was fit and healthy, and thus only represents half the spectrum of physical fitness. Future research should focus on incorporating a more heterogeneous sample.

Limitations

This study has several limitations. Misrepresentation or lack of knowledge during initial screening procedures (hiding an injury and/or medication use, misrepresentation of current lifestyle habits, etc.) could skew sample demographic results. Misrepresentation of current lifestyle habits would most likely result in the sample participants appearing healthier than they actually were (as opposed to unhealthier) and thus, at lower CVD risk. Accuracy of self-reported questionnaires (FLC, Par-Q, and HPAPQ) would also compromise sample demographic and CVD risk assessment results. In terms of health-related fitness assessment, the ability of assessor to accurately monitor, observe, and record fitness assessment results could misrepresent data and compromise correlation analysis. Finally, the validity of the wall-sit test as a measure of health-related fitness could be questioned as no known validity studies have been done, despite the widespread use of this measure in physical therapy and rehabilitation research studies.

Delimitations

The HPAPQ, Par-Q, and FLC revealed that the majority of the sample population was homogenously healthy, active, and making healthy lifestyle choices that reduce CVD risk. This represents only half the spectrum of health and physical fitness, and thus limits the results to a very specific population of young adults.

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Appendix A – Consent and Information Forms

Kine 1113 Personal Information Consent Form
Participant Information Letter
Participant Consent Form

Kine 1113 Personal Information Consent Form

I ________________________________, am 18 years of age or older and consent to the release of all personal health information collected during class or laboratory sessions. I understand that my consent is completely voluntary and that I have the right to decline consent at any time with no penalty to my final grade. In addition, I understand that all personal information that I provide will remain strictly confidential, with no identities revealed. I understand that all data will be securely stored in the School of Kinesiology Lakehead University for a period of 5 years. I also understand that this data may be used in future research studies.

Please check the following classes for which this consent form applies:

☐ Kin 1113 Principles of Health

☐ Kin 1710 Intro to Lifestyle Management

☐ Kin 4610 Advanced Issues in Nutrition

By signing this consent form you provide permission to collect personal information related to Kinesiology course activities. Note that personal information is collected under the authority of section 3 and 14 of the Lakehead University Act and will be used for the administration and operation of the specific course within which the information is collected and for the defense of the University against any claims or litigation concerning the course. Any questions on this collection should be directed to: Director, School of Kinesiology, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario, P7B 5E1; telephone (807) 344-8544.

Signature of student: ______________________Date:__________________

Participant Information Letter

My name is David Thompson and I am a graduate Kinesiology student at Lakehead University currently working under the supervision of Dr. Joey Farrell and Professor Tracey Larocque. You are invited to participate in a study titled: Exploring the Relationship between Health-Related Fitness and Biological Cardiovascular Disease Markers.

The purpose of this study is to explore relationships between simple, non-invasive measures of health-related fitness and biological (blood) markers for cardiovascular disease (CVD) risk. The first part will the completion of a health-related fitness assessment conducted in the Hangar at Lakehead University. The measures used in the assessment battery are: Body Mass Index, Waist Circumference, right angle push-up test, 60 second sit-up test, sit and reach (flexibility) testing, wall squat test, and a 1 mile walk test. There are no foreseeable risks associated with the health-related assessment. Prior to testing, all participants will be informed that their safety is our primary concern and that if at any point in time they feel the assessment is affecting them in a negative manner, they can terminate the testing immediately. This scenario is extremely unlikely to occur, as all assessment measures were chosen because of their ability to assess health with minimal risk. Also, fourth year Kinesiology students are very familiar with and have been previously assessed with the same or similar measures throughout their University course requirements The second part will consist of measuring blood serum levels of the following biological markers associated with CVD risk: High Density Lipoprotein Cholesterol, Low Density Lipoprotein Cholesterol, Total Cholesterol, Triglycerides, and high sensitivity C Reactive Protein. All of these measures have been linked to CVD. The donation of blood will require you to visit one of three LifeLabs Clinics in Thunder Bay. Blood donation will take roughly 10 minutes to complete and be conducted by LifeLabs Services, a company certified in all aspects of blood collection.

Though minimal, you should be aware of the risks associated with the drawing of blood. You may experience a mild stinging or burning sensation when the needle is inserted, with minor swelling or bruising that can last a few days after the procedure. There is also the risk of feeling faint or lightheaded at the sight of blood. Be assured that all precautions will be taken to ensure your safety. Blood will be drawn using trained, qualified personnel. This research study will take only as much blood as absolutely necessary, which is approximately 8 ml. This amount is approximately 2 % of the typical amount given when donating at a blood donor clinic.

Participation in this study is completely voluntary. You have the option to refuse to participate in this study with no effect on your final grade. Full confidentiality will be given to each participant and no names will be revealed. The data for this research project will be stored for five years at Lakehead University with the faculty advisor, Dr. Joey Farrell.

The research has potential benefit to university students by providing them with a CVD risk profile based on a traditional blood lipid panel with the addition of C Reactive protein. This profile will increase student awareness of their individual biological risk for CVD. Individual results will be available to each student in the form of a health report card. The outcome of this study may provide insight into an inexpensive and non-invasive CVD screening strategy.

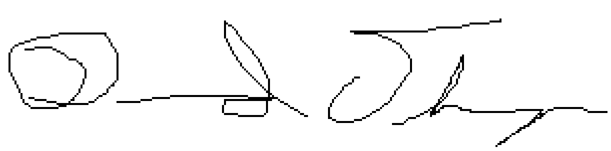
The findings of this project will be available to you upon request.

If you have any questions or concerns, please do not hesitate to contact me at dsthomps@lakeheadu.ca. You may also contact Professor Tracey Larocque at tmlarocq@lakeheadu.ca or Joey Farrell at jfarrell@lakeheadu.ca for additional information. For further information, please contact Sue Wright, Lakehead University's Research Ethics and Administration officer at:

Office of Research
Lakehead University
955 Oliver Road
Thunder Bay, ON P7B 5E1
Tel.: (807) 343-8283
Fax: (807) 346-7749

Thank you for your time and consideration.

Sincerely,



David Thompson

Participant Consent Form

I ________________________________ agree to participate in the study titled: Exploring the Relationship Between Health-Related Fitness and Biological Cardiovascular Disease Markers. I have read the attached information letter and understand all potential risks and benefits associated with participation in this study. I understand that my participation is voluntary and that I have the right to decline at any time with no penalty to my final grade. In addition, I understand that all personal information that I provide will remain strictly confidential, with no identities revealed. I understand that all data will be securely stored at Lakehead University in a locked filing cabinet under Dr. Joey Farrell for a period of 5 years. I also understand that the research findings will be available to me upon request.

Signature of student: ______________________Date:__________________

Appendix B – Demographic Information

Fantastic Lifestyle Checklist
Healthy Physical Activity Participation Questionnaire
Physical Activity Readiness Questionnaire

TOOL #22 FANTASTIC LIFESTYLE CHECKLIST

INSTRUCTIONS: Unless otherwise specified, place an 'X' beside the box which best describes your behaviour or situation in the past month. Explanations of questions and scoring are provided on the next page.

FAMILY FRIENDS	I have someone to talk to about things that are important to me	almost never	seldom	some of the time	fairly often	almost always
	I give and receive affection	almost never	seldom	some of the time	fairly often	almost always
ACTIVITY	I am vigorously active for at least 30 minutes per day e.g., running, cycling, etc.	less than once/week	1-2 times/week	3 times/week	4 times/week	5 or more times/week
	I am moderately active (gardening, climbing stairs, walking, housework)	less than once/week	1-2 times/week	3 times/week	4 times/week	5 or more times/week
NUTRITION	I eat a balanced diet (see explanation)	almost never	seldom	some of the time	fairly often	almost always
	I often eat excess 1) sugar, or 2) salt, or 3) animal fats, or 4) junk foods.	four of these	three of these	two of these	one of these	none of these
	I am within ____kg of my healthy weight	not within 8 kg	8 kg (20 lbs)	6 kg (15 lbs)	4 kg (10 lbs)	2 kg (5 lbs)
TOBACCO TOXICS	I smoke tobacco	more than 10 times/week	1 - 10 times/week	none in the past 6 months	none in the past year	none in the past 5 years
	I use drugs such as marijuana, cocaine	sometimes				never
	I overuse prescribed or 'over the counter' drugs	almost daily	fairly often	only occasionally	almost never	never
	I drink caffeine-containing coffee, tea, or cola	more than 10/day	7-10/day	3-6/day	1-2/day	never
ALCOHOL	My average alcohol intake per week is____ (see explanation)	more than 20 drinks	13-20 drinks	11-12 drinks	8-10 drinks	0-7 drinks
	I drink more than four drinks on an occasion	almost daily	fairly often	only occasionally	almost never	never
	I drive after drinking	sometimes				never
SLEEP SEATBELTS STRESS SAFE SEX	I sleep well and feel rested	almost never	seldom	some of the time	fairly often	almost always
	I use seatbelts	never	seldom	some of the time	most of the time	always
	I am able to cope with the stresses in my life	almost never	seldom	some of the time	fairly often	almost always
	I relax and enjoy leisure time	almost never	seldom	some of the time	fairly often	almost always
	I practice safe sex (see explanation)	almost never	seldom	some of the time	fairly often	always
TYPE of behaviour	I seem to be in a hurry	almost always	fairly often	some of the time	seldom	almost never
	I feel angry or hostile	almost always	fairly often	some of the time	seldom	almost never
INSIGHT	I am a postive or optimistic thinker	almost never	seldom	some of the time	fairly often	almost always
	I feel tense or uptight	almost always	fairly often	some of the time	seldom	almost never
	I feel sad or depressed	almost always	fairly often	some of the time	seldom	almost never
CAREER	I am satisfied with my job or role	almost never	seldom	some of the time	fairly often	almost always

STEP 1 Total the X's in each column → ☐ ☐ ☐ ☐ ☐

STEP 2 Multiply the totals by the numbers indicated (write your answer in the box below) → 0 x 1 x 2 x 3 x 4

STEP 3 Add your scores across the bottom for your grand total → ☐ + ☐ + ☐ + ☐ = ☐

Grand total
(see explantion)

TOOL #21 HEALTHY PHYSICAL ACTIVITY PARTICIPATION QUESTIONNAIRE

DETERMINING THE HEALTH BENEFITS OF YOUR PHYSICAL ACTIVITY PARTICIPATION IS AS EASY AS A, B, C ...

A. Answer the following questions:

#1 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 a rapid heart beat?

- ☐ At least three times
- ☐ Normally once or twice
- ☐ Rarely or never

#2 Intensity

When you engage in physical activity, do you have the impression that you:

- ☐ Make an intense effort
- ☐ Make a moderate effort
- ☐ Make a light effort

#3 Perceived Fitness

In a general fashion, would you say that your current physical fitness is:

- ☐ Very Good
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Very Poor

B. Circle your score for each answer and total your score.

Scoring of Questionnaire Responses

Item	Male	Female	Male	Female	Male	Female
#1 Frequency	Rarely or never		Normally once or twice		At least three times	
	0	0	2	3	3	5
#2 Intensity	Light effort		Moderate effort		Intense effort	
	0	0	1	2	3	3
#3 Perceived Fitness	Very Poor or Poor		Average		Good or Very Good	
	0	0	3	1	5	3

Total Score = ____________

C. Determine your health benefit rating based on your score from B.

Health Benefit Zone	Total Score
Excellent	9–11
Very Good	6–8
Good	4–5
Fair	1–3
Needs Improvement	0

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ____ DATE ________________________________

SIGNATURE OF PARENT ____ WITNESS ________________________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

Appendix C - Health-Related Fitness Assessment Protocol

Assessment of Body Composition

Body Mass Index

Waist Circumference

Assessment of Cardiorespiratory Fitness

The Rockport Walk Test

Assessment of Flexibility

The Modified YMCA Sit and Reach Test

Assessment of Muscular Strength and Endurance

90 Degree Push-ups

Partial Curl-ups

Wall-Sits

Testing Environment

All testing will take place in the Fieldhouse and the Hangar at Lakehead University. Testing will begin in SB 1027, located in the Fieldhouse at Lakehead University. All testing will be monitored by Prof. Tracey Larocque and graduate Student Dave Thompson. All tests will be administered in the same order, as follows: 1) Body Composition Measures, 2) Cardiorespiratory Fitness Measure, 3) Flexibility Measure, and 4) Muscular Strength and Endurance Measures. Participants will be allowed a maximum of 5 minutes to recover between tests, with overall assessment requiring approximately 50 minutes to complete. Participants will be assessed in groups of approximately 25.

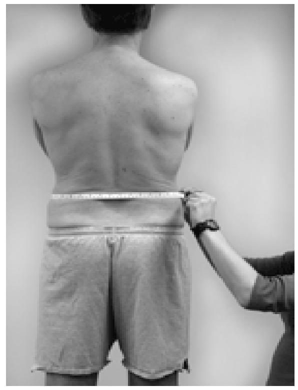
Assessment of Body Composition

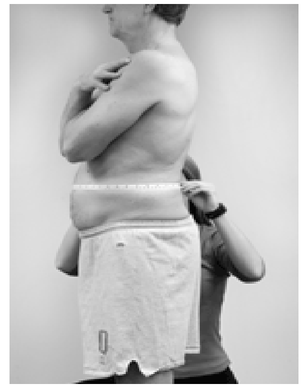
Initially, measures of height and weight will be taken in SB 1027, located in the Fieldhouse. When measuring both height and weight, assessors will instruct participants to remove footwear and any excess clothing (jackets, sweaters, etc.). Height will be measured using a wall-mounted stadiometer, and weight will be measured using a digital scale. Assessor is to record weight in pounds and height in inches to the nearest first decimal place. Next, assessors will conduct waist circumference measures using National Institute of Health Guidelines. Room dividers will be provided for individuals that require additional privacy. National Institute of Health Waist Circumference protocol is as follows:

Waist Circumference

Using the NIH (1998) protocol, the waist circumference measurement should be taken at the top of the iliac crest. To find this landmark, palpate the upper right hipbone of the client until you locate the uppermost lateral border of the iliac crest.

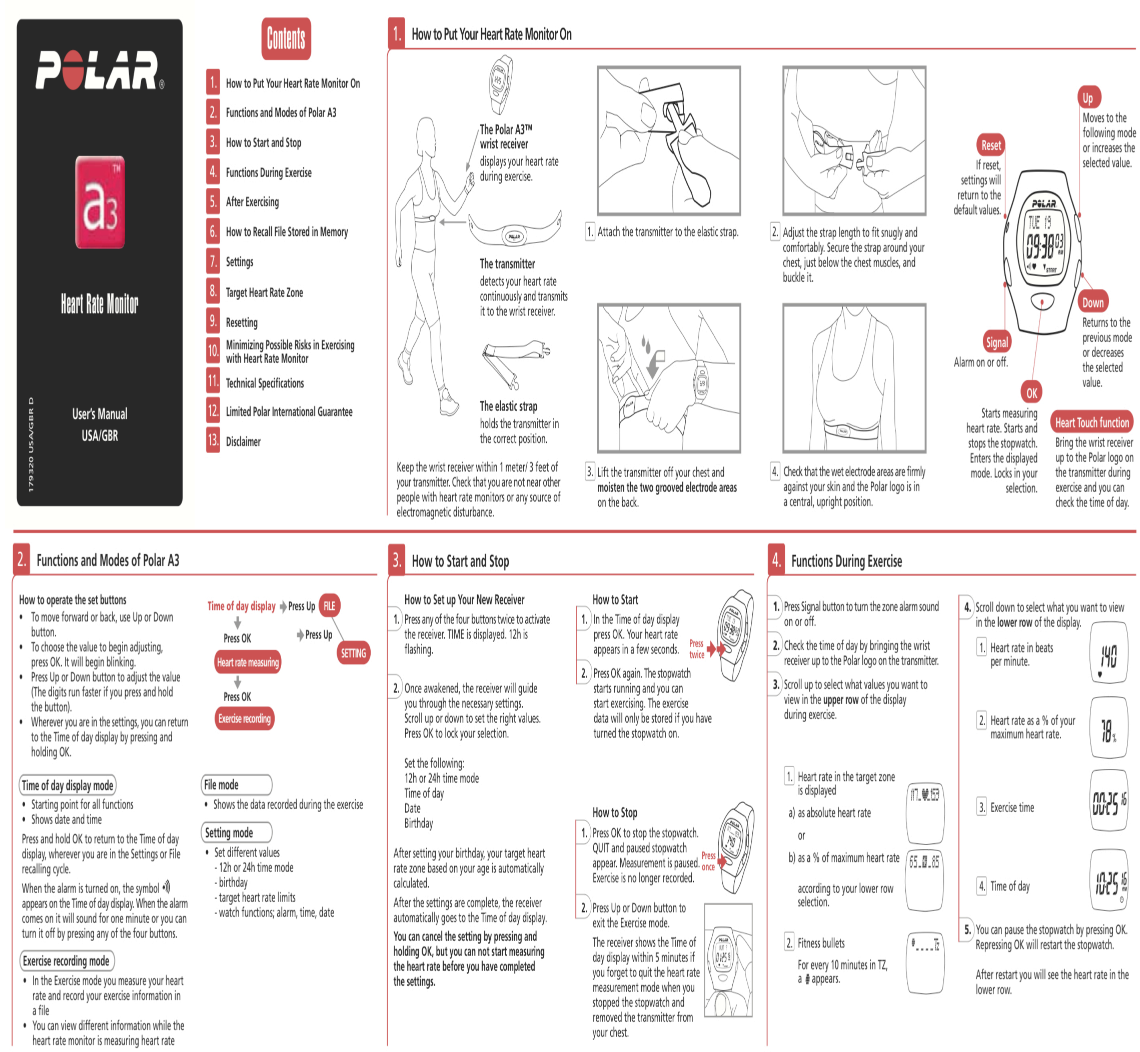
Position the tape directly around the abdomen so that the inferior edge of the tape is at the level of the landmarked point. Use a cross-handed technique to bring the zero line of the tape in line with the measuring aspect of the tape. Ensure that the measuring tape is positioned in a horizontal plane around the abdomen. Apply tension to the tape to ensure it is snug, without causing indentation to the skin. At the end of a normal expiration, take the measurement to the nearest 0.5cm. Measurement is conducted twice.





Polar Heart Rate Monitors

Immediately following waist circumference measures participants will be equipped with Polar Heart Rate Monitors. Room dividers will be made available for participants that require additional privacy. Instructions for equipping Polar Heart Rate Monitors are as follows:



Assessment of Cardiorespiratory Fitness

After Polar Heart Monitors have been equipped on each participant, participants and assessors will proceed to the indoor track located in the Hangar at Lakehead University to conduct the Rockport Walk Test. Initially, each participant will be instructed to perform 1 warm-up lap around the track followed by light stretching. Assessors will instruct participants that the test will be conducted using the inner most lane on the track. The Rockport Walk Test is a 1 mile walk test, which means that participant complete 8 laps on the inner most track. Assessors will time participants and record heart rate (beats per minute) and time to completion (in minutes and seconds). The Protocol for the Rockport Walk Test is described below.

The Rockport Walk Test

1. The Rockport Walk Test is a sub-maximal measure of aerobic capacity that is conducted on an indoor track.

2. Before test begins, participants are asked to conduct a brief warm up involving a couple of laps around the track followed by some light stretching to introduce heat into the major muscle groups and reduce the chance of injury.

2. After warm up, subject is instructed to walk (not run) as fast as possible for one mile. Emphasis will be placed on the importance of walking (no flight phase) vs running (flight phase).

3. Heart rate and walking time will be recorded immediately after one mile is completed.

Immediately following the Rockport Walk Test, Polar Heart Rate monitors will be removed and cleaned. Participants will be allowed a maximum of 5 minutes of rest and may drink some fluids if necessary. The next portion of testing will occur in either the Cardio Room adjacent to the indoor Track or in the Auxiliary gym adjacent to the LU weight room.

Assessment of Flexibility

Flexibility will be assessed following the Rockport Walk Test. Stations will be set-up in either the Cardio Room or the Auxiliary Gym. Protocol for the Modified Sit and Reach Test is as follows:

The YMCA Sit and Reach Test

1. Start by conducting a brief warm-up and some light stretching to introduce heat into muscle to reduce the likelihood of injury. The Rockport Walk Test covers this portion of the assessment protocol. Remove any footwear.

2. Assume a seated position with knees extended, feet roughly 12 inches apart. Place the heel of your foot on the 38 cm mark. The 38 cm mark is the zero mark meaning that an inability to reach this far indicates a negative score, and reaching beyond this point a positive score.

3. Place one hand on top of the other and lean forward as far as you can in a slow, controlled manner, exhaling and lowering your chin as you do so. Legs must be kept straight during the test. Remember to reach forward in smooth, controlled manner to avoid injury (emphasize no bouncing or jerking forward). Have partner measure from the point of the middle digit at furthest reach using a ruler.

4. Repeat test twice and take the average of both scores.


Starting Position   Measurement Position

Immediately following the YMCA Sit and Reach Test, assessors will proceed to the next station to measure upper body muscular strength and endurance. Participants should not require rest following the YMCA Sit and Reach Test.

Assessment of Upper Body Muscular Strength and Endurance

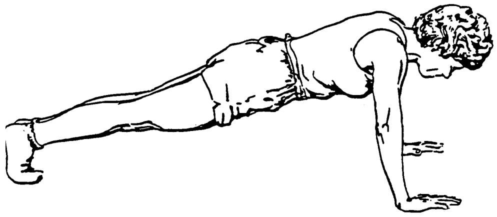
Upper body muscular strength and endurance will be measured using ACSM's 90- degree push-up test. Prior to assessment, all participants have been instructed to refrain from wearing excessively baggy clothing that may obstruct the view of the angle at the elbow. Protocol for the 90-degree push-up test is as follows:

90-Degree Push-up Test

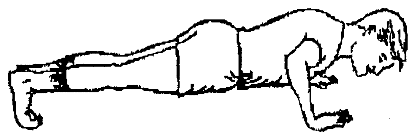
1. Start in the resting or front leaning position with hands approximately shoulder width apart, elbows in close to your abdomen, and feet together. The arms, back, buttocks and legs must be straight from head to heels and must remain so throughout the push-up. Shoes may/may not be worn.

2. Begin the push-up by bending the elbow and lowering the entire body until the top of the upper arms, shoulders, and lower back are aligned and are parallel to the deck. Your elbow should be flexed at 90 degrees.

3. Return to the resting position by extending the elbows until the arms are straight. Women perform the test with the starting position being from the knees. Participant is instructed to perform as many repetitions as possible until failure or proper form can no longer be maintained. Assessor should be positioned parallel to participant so that the angle at the elbow is clearly visible.



Male Start Position



Male Finish Position

Arm Position

Female Start and Finish Positions

Following the 90-degree push-up test, participants will be allowed a maximum of 5 minutes of rest. Participants will then proceed to the next station to assess core muscular strength and endurance.

Core Muscular Strength and Endurance

Core muscular strength and endurance will be assessed using ACSM 7th Edition partial curl-up test. Testing protocol is as follows:

The Partial Curl-Up Test

1. Assume a supine position on a mat with the low back and shoulders flat against the floor and the knees bent at a 90-degree angle. Arms are placed on top of legs, palms facing down.

2. Tighten your stomach muscles and flatten your back against the floor. Tuck your chin to your chest and with your hands stretched out in front of you, curl your upper body forward until your shoulders clear the floor and your hands touch your kneecaps. It helps to breathe out as you lift your shoulders. Relax and return to turn to starting position.

3. Perform as many curl-ups as possible without pausing for 60 seconds.

Starting Position End Position

Following the partial curl-up test, participants will be allowed a maximum of 5 minutes of rest. Participants will then proceed to the final station to assess lower body muscular strength and endurance.

Assessment of Lower Body Muscular Strength and Endurance

Lower body muscular strength and endurance will be assessed using the 90 degree wall squat test. Testing protocol is as follows:

The Wall Squat Test

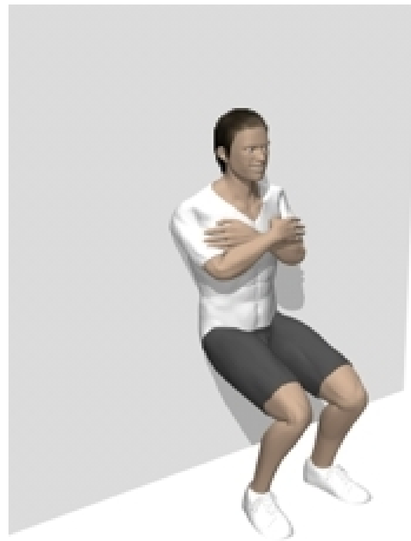
1. Participant stands with back flat against a wall, feet out from the wall.

2. Participants slides down the wall and assumes the starting position, which has the thighs parallel to the floor. Feet are adjusted out from the wall to make a right angle at the knees and hips. Arms are crossed across the chest.

3. Timing begins when participant reaches starting position. Participant is instructed to hold position as long as possible.

4. Test is terminated when participant can no longer hold end position.

Start Position



End Position

Appendix D – Normative Data

Body Mass Index

Waist Circumference

The Rockport Walk Test

YMCA Modified Sit and Reach Test

90-Degree Push-up

Partial Curl-up

Body Mass Index Guidelines (World Health Organization, 2004)

Body mass index is an estimate of body fat percentage based on height and weight, expressed in $kg/m^{2.}$ It is calculated using the following equation: Weight in pounds / $(\text{Height in inches})^2$ x 703. BMI is classified according to the following table:

Classification	**BMI(kg/m^2)**	
	Principal cut-off points	**Additional cut-off points**
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34-99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Waist Circumference Guidelines (NIH, 1998)

Waist circumference is a measure of abdominal obesity and is a proven indicator of CVD risk. The NIH method for measuring waist circumference is done at the superior border of the iliac crest. Guidelines for waist circumference are as follows:

Waist Circumference > 35 inches (88 cm) for women (Increased Risk)
Waist Circumference > 40 inches (102 cm) for men (Increased Risk)

The Rockport Walk Test (Heyward, 2006)

TABLE I. AEROBIC FITNESS CATEGORIES FOR MEN AND WOMEN

Fitness Category VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)

	Age	Excellent	Very Good	Good	Average	Fair	Poor	Very Poor
♂	18-20	>63	62-57	56-51	50-46	45-39	38-33	<33
	21-25	>62	62-56	55-51	50-45	44-38	37-32	<32
	26-30	>59	59-55	54-48	47-42	41-36	35-30	<30
♀	18-20	>53	53-48	47-43	42-38	37-33	32-28	<28
	21-25	>50	50-46	45-42	41-36	35-32	31-27	<27
	26-30	>48	48-44	43-40	39-35	34-31	30-26	<26

Table derived from graphs in Shvartz, E., & Reibold R.C. (1990). Aerobic fitness norms for males and females aged 6 to 75 years: A review. *Aviation, Space, and Environmental Medicine*, 61, 31-11.

The YMCA Modified Sit and Reach Test (ACSM 7th Ed.)

Sit and Reach Flexibility Norms for Men (inches)

Age (years)	15 - 19	20 – 29	30 – 39	40 - 49	50 – 59	60 - 69
Excellent	15+	15+	14.6+	13.4+	12.6+	11.8+
Desirable	13 - < 15	13 - < 15	12.6 - < 14.6	11 - < 13.4	10.6 - < 12.6	9.5 - < 11.8
Needs Impr.	9.5 - < 13	9.8 - < 13	9.1 - < 12.6	7.1- < 11	6.3 - < 10.6	5.9 - < 9.5
Caution	< 9.5	< 9.8	< 9.1	< 7.1	< 6.3	< 5.9

Sit and Reach Flexibility Norms for Women (inches)

Age (years)	15 - 19	20 – 29	30 – 39	40 – 49	50 – 59	60 - 69
Excellent	16.5+	15.7+	15.4+	14.6+	14.6+	13.4+
Desirable	14.6 - < 16.5	14.1 - < 15.7	13.8 - < 15.4	13 - < 14.6	12.6 - < 14.6	11.8 - < 13.4
Needs Impr.	11.4 - < 14.6	11 - < 14.1	10.6 - < 13.8	9.8 - < 13	9.8 - < 12.6	9.1 - < 11.8
Caution	< 11.4	< 11	< 10.6	< 9.8	< 9.8	< 9.1

90-Degree Push-up Test (ACSM 7th Ed.)

Push-Up Test (Males)

Age	*20-29*	*30-39*	*40-49*	*50-59*	*60-69*
Excellent	36	30	25	21	18
Very Good	35	29	24	20	17
	29	22	17	13	11
Good	28	21	16	12	10
	22	17	13	10	8
Fair	21	16	12	9	7
	17	12	10	7	5
Needs Improvement	16	11	9	6	4

Push-Up Test (Females)

Age	*20-29*	*30-39*	*40-49*	*50-59*	*60-69*
Excellent	30	27	24	21	17
Very Good	29	26	23	20	16
	21	20	15	11	12
Good	20	19	14	10	11
	15	13	11	7	5
Fair	14	12	10	6	4
	10	8	5	2	2
Needs Improvement	9	7	4	1	1

The Partial Curl-Up Test (ACSM 7th. Ed)

Sit-Up Norms for Men

Age (years)	15 - 19	20 - 29	30 – 39	40 - 49	50 - 59	60 - 69
Excellent	46+	41+	34+	30+	25+	21+
Desirable	41 - < 46	36 - < 41	30 - < 34	25 - < 30	21 - < 25	15 - < 21
Needs Impr.	33 - < 41	29 - < 36	22 - < 30	17 - < 25	13 - < 21	7 - < 15
Caution	< 33	< 29	< 22	< 17	< 13	< 7

Sit-Up Norms for Women

Age (years)	15 - 19	20 - 29	30 – 39	40 – 49	50 - 59	60 - 69
Excellent	40+	34+	27+	23+	17+	15+
Desirable	35 - < 40	29 - < 34	23 - < 27	18 - < 23	11 - < 17	10 - < 15
Needs Impr.	27 - < 35	21 - < 29	15 - < 23	7 - < 18	3 - < 11	2 - < 10
Caution	< 27	< 21	< 15	< 7	< 3	< 2