THE EFFECTS OF FLOORBALL ON CARDIOVASCULAR FITNESS AND BODY COMPOSITION OF YOUNG ADULTS

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DEDICATION

This dissertation is dedicated to my wife Cari and my children Micah, Matthew and Mia. Thank you for your love, support, and encouragement.

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ABSTRACT

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The purpose of the study was to compare cardiovascular fitness and body composition measures before and after 7 weeks of floorball versus steady state exercise (SSE) in healthy adolescents. Specifically, this study determined differences in maximal oxygen uptake, heart rate, rate of perceived exertion, body mass index, waist circumference, body fat, and enjoyment between floorball and SSE. Steady state exercise included walking and running on a treadmill. The study involved 31 male and female participants who were assigned to either the floorball (n = 14) or the SSE group (n = 17). Maximal oxygen consumption, body mass index, waist circumference, and percent body fat were measured in the beginning and at the end of the study. Both of the groups met twice a week for 40 min. Exercise sessions included a 5-min warm-up and cool down, 20 min of exercise for the floorball (FRBL) group, and 30 min of exercise for the SSE group. The participants in the FRBL group played floorball for 2 min followed by 1 min of rest. The SSE group exercised on a treadmill at 60-85% of HRR. Heart rate, rate of perceived exertion, and perceived enjoyment of exercise were measured throughout the exercise sessions. Mixed design MANOVA or ANOVAs were used to analyze the data with a significance level of .05. Maximal oxygen uptake increased significantly in the

FRBL group (pre: 38.21 ± 7.94 ml/kg/min, post: 39.91 ± 7.55 ml/kg/min), whereas the SSE group did not see a significant increase (pre: 37.72 ± 7.53 ml/kg/min, post: 38.09 ± 7.55 ml/kg/min) following the 7-week intervention. A significant group main effect for peak HR across the 7 weeks of exercise was found (main effect means = 187.9 ± 5.7 and 175.0 ± 4.5 bpm for FRBL and SSE groups, respectively) but not for average HR. There were no significant improvements in any of the body composition measures. This study demonstrated that floorball can be an efficient means of improving cardiovascular fitness with normal to overweight young adults.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Physical inactivity plays a major role in the development of many chronic diseases. In fact, physical inactivity is a risk factor for the leading causes of death worldwide, including heart disease and cancer (Kohl et al., 2012). In the U.S., only 21% of the adult population meet the current physical activity guidelines (Centers for Disease Control and Prevention, 2014). Likewise, children and adolescents do not acquire enough physical activity to meet the recommendations. Indeed, the Centers for Disease Control and Prevention (2014) indicate that 7 out of 10 high school students do not achieve the recommended amount of physical activity. Healthy habits developed during adolescence may be carried into adulthood, thereby positively affecting the cardiometabolic health. Dumith, Gigante, Domingues, and Kohl (2011) stated that physical activity decreases by 65% throughout adolescence. Physical inactivity is also a risk factor for obesity. Childhood obesity rates have more than doubled and quadrupled in children and adolescents, respectively, in the past 30 years. More than one-third of children and adolescents were overweight or obese in 2012 (Ogden, Carroll, Kit, & Flegal, 2014).

Current physical activity guidelines from the Centers for Disease Control and Prevention (2019) recommend that children and adolescents age 6-17 years should complete 60 min or more of physical activity per day. Most of that time should be spent performing moderate- or vigorous-intensity exercise. At least three days per week should include activities that are vigorous. The activities chosen should be enjoyable and age-appropriate. As part of the 60 min, it is also recommended to include muscle and bone strengthening physical activities at least three days per week.

To achieve vigorous intensity during exercise, high-intensity interval training (HIIT) might be appropriate. This type of training involves alternating high-intensity exercise with light exercise or rest (Thompson, 2017; Norton, Norton, & Sadgrove, 2010). The goals and fitness level of the person will affect the duration and intensity of the intervals (Powers & Howley, 2015). An American College of Sports Medicine (ACSM) survey of worldwide fitness trends for 2018 revealed that HIIT was the most popular according to health and fitness professionals (Thomson, 2017). With an increasing number of facilities offering classes in HIIT, there is an increased scientific interest in studying the effects of HIIT (Logan, Harris, Duncan, & Schofield, 2014). This type of training may offer similar or superior benefits when compared to continuous aerobic exercise. For example, 2-6 weeks of HIIT can enhance maximal oxygen uptake (VO_2max), insulin sensitivity, lipid oxidation, systolic blood pressure, and body composition in unfit, sedentary individuals (Whyte, Gill, & Cathcart, 2010).

There is limited research regarding the effects of HIIT on adolescents. Previous researchers have suggested that the effects of various HIIT protocols, the differences between continuous aerobic exercise and HIIT, and the enjoyment of HIIT by adolescents should be examined (Logan, Harris, Duncan, & Schofield, 2014). It may be more appealing for adolescents to perform more intense exercise that is short in duration (Crisp, Fournier, Licari, Braham, & Guelfi, 2012). Also, it is important to integrate enjoyment and fun into activities for adolescents. Finding new ways to help children and adolescents to become more active may decrease the health consequences of physical inactivity and obesity in these populations.

One strategy to incorporate the aspects of HIIT is to play a sport that is structured to elicit periods of high- and low-intensity exercise. Children and youth are not attaining enough activity to receive noticeable health and fitness benefits in many sports, such as baseball (Bergeron, 2007; Leek et al., 2011).

Floorball can be an excellent, easy, and fun way to incorporate HIIT. Floorball is similar to floor hockey and is considered as one of the fastest growing sports in the world ("Floorball is One," 2013). The rules and equipment of floorball make it safe and easy to play. The sticks are light and short, and the ball used makes floorball a fast-paced game that incorporates quick sprints. There is no body contact except incidental shoulder-to-shoulder contact. Floorball is played competitively and recreationally, and several physical education programs in the US have adopted the sport. Participation in the sport is low-cost and it is easy to learn, making it an excellent coed sport for young and old.

Statement of the problem

The purpose of the study was to compare cardiovascular fitness and body composition measures before and after seven weeks of floorball versus SSE in healthy adolescents. It is critical to find alternative methods of exercise to encourage physical activity in adolescents. Physical activity plays a key role in preventing cardiovascular disease (CVD) and obesity. Brief periods of high-intensity activity might be more natural, attractive, and easier to perform over time versus moderate-intensity physical activity (Crisp et al., 2012).

Hypotheses

The following hypotheses were analyzed at the .05 level of significance:

1. There is no significant difference within each group on VO_2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds over time.
2. There is no significant difference between the groups on VO2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds.
3. There is no significant interaction of training groups and time on VO2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds.

Definitions

Adolescent: The World Health Organization (WHO) defines an adolescent as any young person between the ages of 10 and 19 (2017).

Aerobic exercise: Planned physical activity that uses large muscle groups, can be maintained continuously, and is rhythmic in nature (Wahid et al., 2016). This type of exercise is using oxygen and amino acids, carbohydrates, and fatty acids during the aerobic metabolism.

Anaerobic exercise: Intense physical activity of short duration that is fueled by the energy systems within the muscles and is not dependent on oxygen (Pescatello & American College of Sports Medicine, 2014). Energy is supplied by ATP-PC system and glycolysis.

Body composition: The component tissues of the body. It is most often used to refer to the relative percentages of fat and fat-free tissues.

Body Mass Index (BMI): BMI is a person's weight in kilograms divided by his or her height in meters squared. It is often used to assess overweight and obesity.

Cardiorespiratory fitness: Ability to perform large muscle, dynamic, moderate-to high-intensity exercise for prolonged periods. Cardiorespiratory fitness depends on the functional state of the respiratory, cardiovascular, and skeletal muscle systems.

Heart Rate Reserve (HRR): The difference between maximal heart rate (HR) and resting HR. HRR is often used to prescribe the intensity of an exercise session.

High-intensity Interval Training (HIIT): Varying the exercise intensity from high-intensity to low-intensity or rest at fixed intervals during a single exercise bout.

Maximal Oxygen Consumption (VO_2max): Maximal oxygen uptake or the maximum volume of oxygen that can be utilized in 1 min during maximal or exhaustive exercise. It is most commonly expressed as milliliters of oxygen used in one minute per kilogram of body weight (ml/kg/min).

Moderate intensity physical activity: Physical activity that has an absolute intensity of 3.0 to 5.9 METs, HRR of 40-59% or RPE of 12-13 (Powers & Howley, 2015).

Peak Heart Rate (peak HR): For the purposes of this study, peak heart rate is defined as the highest heart rate achieved during either the floorball or steady-state exercise sessions.

Physical Activity Enjoyment Scale (PACES): A 7-point Likert-type scale to measure perceived enjoyment of physical activity validated by Kendzierski and DeCarlo

(1991). This questionnaire includes 16 items related to different aspects of enjoyment.

Physical Activity Readiness Questionnaire + (PAR-Q+): A self-administered exercise-clearance questionnaire for individuals between the ages of 15 and 69 years (Bredin, Gledhill, Jamnik, & Warburton, 2013).

Rating of Perceived Exertion (RPE): RPE is often used as a primary way to assess exercise intensity. The Borg 6-20 RPE scale or 0-10 scale may be used. Perceived exertion is how hard someone feels like his or her body is working when performing physical activities.

Steady State Exercise (SSE): Exercising at the same intensity throughout an exercise routine. This is achieved by maintaining the HR and RPE at a steady level.

Vigorous intensity physical activity: Physical activity that has an absolute intensity of 6.0 METs or more, HRR of 60-89% or RPE of 14-17 (Powers & Howley, 2015).

Assumptions

The assumptions of this study were:

1. Participants will follow the assigned programs.
2. Participants will maintain their habitual lifestyle and their normal diet during the study.
3. Participants will accurately rate their perceived enjoyment of exercise.
4. Participants will exert maximum effort during the VO_2max test.

Limitations

The present study was conducted with the following limitations.

1. Participants were adolescents.
2. Participants self-reported the physical activity they did on their own.
3. Diet and other physical activity might have affected the body composition measurements.
4. There was no random assignment.

Significance of the Study

There have been no studies investigating floorball as an exercise mode with overweight adolescents and young adults. Therefore, it is necessary to determine how floorball affects cardiovascular fitness and body composition in this population. The results of this study will be useful for teachers and other professionals who work with adolescents. Floorball might be an enjoyable, intermittent type of physical activity that might be a more efficient way to increase cardiovascular fitness and lower body composition than SSE especially with overweight and obese young adults.

The objective of this study was to investigate the influence of playing floorball versus performing SSE on cardiovascular fitness and body composition in young adult participants in order to determine if floorball can be used as an activity to help decrease the number of adolescents and young adults who are physically inactive and those who are overweight or obese. The number of people with chronic diseases such as heart disease, type 2 diabetes, and obesity are rapidly increasing. In 2012, about half of the adults in the U.S. had one or more chronic health conditions (Ward, Schiller & Goodman, 2014). One of the risk factors for chronic disease is lack of exercise. Often unhealthy behaviors such as lack of exercise and poor nutrition are initiated during adolescence, setting a stage for later disease. Therefore, it is important to find new methods of training to encourage physical activity with adolescents or young adults.

CHAPTER II

REVIEW OF LITERATURE

The purpose of the study was to compare cardiovascular fitness and body composition measures before and after seven weeks of floorball versus SSE in healthy young adults. Specifically, this study was used to determine differences in VO_2max, heart rate, RPE, BMI, waist circumference, body fat, and enjoyment.

The following literature review will summarize the existing research on cardiovascular fitness and body composition related to floorball and HIIT. First, the research related to cardiovascular and body composition responses of playing floorball and related sports will be summarized. Next, literature on cardiovascular fitness and body composition related to HIIT, HIIT compared to SSE, and HIIT among adolescents will be examined. The databases used to search for articles were SPORTDiscus, PubMed, ERIC, and Academic Search Complete. The key words used in the search included health benefits of physical activity, floorball, HIIT, SSE, adolescents, VO_2max, body composition, and enjoyment.

Energy Systems

Physical activity requires a constant supply of adenosine triphosphate (ATP). Limited amounts of ATP can be stored by muscle cells, and therefore, the body needs to have ways to produce ATP during physical activity. Adenosine triphosphate can be produced either without oxygen (anaerobic) or with oxygen (aerobic). The ATP-

Phosphocreatine (PC) system and glycolysis are ways for the body to produce ATP without oxygen, and oxidative formation is a way to produce ATP using oxygen.

The energy for physical activities comes from a combination of aerobic and anaerobic systems (Gastin, 2001). Both energy systems are active at any given time. However, the higher the intensity of physical activity, the greater the contribution of anaerobic production of ATP. Also, the duration of physical activity affects the type of energy system utilized the most. For example, long duration physical activities rely primarily on the aerobic system.

The fastest way to produce ATP is through the ATP-PC system. Short-term, high-intensity activities lasting up to 6 s rely heavily on this system (Baechle & Earle, 2016). The ATP-PC system is also active at the start of all physical activities (Gastin, 2001). If the exercise duration lasts beyond 6 s, but less than 2 min and is intense, the body relies heavily on glycolysis to produce the energy needed for the activity (Baechle & Earle, 2016). Glycolysis is the breakdown of carbohydrates, either glycogen or glucose, to pyruvate or lactate. Most of the work intervals in HIIT programs are between 10-120 s, and therefore, they rely heavily on glycolysis to produce ATP. Energy produced via the ATP-PC system and glycolysis is often called anaerobic exercise.

The oxidative system is the primary way for the body to produce ATP for activities lasting longer than 2 min and those that are low-intensity (Baechle & Earle, 2016). These types of physical activities are often referred to as aerobic exercise. Oxidative phosphorylation, or aerobic production of ATP, takes place in the mitochondria and is a result of a complex interaction between the Krebs cycle and the electron transport chain.

Physiological Responses during Physical Activity

There are several physiological responses that occur during physical activity. Heart rate increases proportionally with intensity. There is also a proportional increase in stroke volume (i.e., the amount of blood pumped from the left ventricle in one beat) up to 40% VO_2max. Cardiac output (i.e., the amount of blood pumped from the heart in one minute) therefore increases since cardiac output equals heart rate times stroke volume (SV). There is a linear increase in systolic blood pressure with an increased intensity of exercise. Diastolic blood pressure decreases slightly or remains unchanged. Blood flow to active muscles increases and the reduction of blood flow to less active organs, such as the kidneys and liver, occurs. Arteriovenous oxygen difference (i.e., difference between oxygen content of arterial and venous blood) also increases. Pulmonary ventilation and oxygen consumption are increased as well when compared to rest. In addition to these changes, the acid-base balance is altered. Especially during near maximal exercise, there is a decrease in blood and muscle pH. This is caused by an increase in hydrogen ions and lactate production (Powers & Howley, 2015).

There are also several hormonal events taking place during physical activity. The sympathetic nervous system suppresses the release of insulin, and there is a decrease in the insulin concentration during physical activity (Galbo, Host & Christensen, 1975). Glucagon concentration increases as well as cortisol concentration when the exercise intensity exceeds 60% of VO_2max (Davies & Few, 1973). There is also an increase in growth hormone, epinephrine, and norepinephrine during exercise (Powers & Howley, 2015).

When we perform physical activities, there are also several neural events occurring. The first step in performing voluntary movement includes subcortical and cortical areas of the brain sending a signal to the association areas of the cortex which forms a blueprint of the planned movement. The signal is then sent to the cerebellum and the basal nuclei which refine the planned movement. After that, it is sent through thalamus to the motor cortex which is the final executor of the motor plan. Finally, the message to move is delivered to the motor units and skeletal muscles and the execution of the desired movement can take place (Powers & Howley, 2015).

Body Composition

Over two-thirds of US adults are overweight or obese and over one-third are obese (Centers for Disease Control and Prevention, 2014). Obesity is also prevalent among children and adolescents. Approximately 17% of children and adolescents aged 2-19 years are obese (Centers for Disease Control and Prevention, 2014). Obesity is associated with 5 of the 10 leading causes of death in industrialized countries including atherosclerosis, heart disease, cancer, stroke, and type 2 diabetes. Therefore, it is very important to not only assess body composition, but also provide guidance on how to achieve a healthy body weight.

There are several ways to measure body composition. Anthropometric methods include BMI, waist circumference and skinfold measurements. Body mass index is an easy method of screening for overweight or obesity. A person with a BMI between 25 and 29.9 kg/m^2 is classified as overweight, and a BMI over 30 kg/m^2 is classified as obese (Nuttall, 2015). Waist circumference is an indirect assessment of abdominal adiposity. Gender-specific circumference cutoff values are used to classify obesity. Disease risk rises significantly with a waist circumference of more than 35 inches in women and more than 40 inches in men (Seidell, 2010). Skinfold measurement involves pinching the skin and subcutaneous fat in specific locations to estimate the amount of body fat. The most commonly used values to define obesity are > 25% in men and > 35% in women (Powers & Howley, 2015).

The pattern of body fat distribution is recognized as an important predictor of the health risks of obesity. Waist circumference provides information about the distribution of fat in the abdomen. The presence of android obesity, which is characterized by more fat in the trunk or abdominal fat, may lead to an increased risk of hypertension, metabolic syndrome, type 2 diabetes, dyslipidemia, coronary artery disease, and premature death compared with individuals who demonstrate gynoid or gynecoid obesity (i.e., fat distributed in the hips and thighs; Thompson, Gordon, & Pescatello, 2010). The extra abdominal fat crowds the organs, and when metabolized, it can raise blood cholesterol levels and lower the body's sensitivity to insulin (Boyle & Long, 2007). There is a higher lipolytic activity observed in visceral adipose tissue than in subcutaneous adipose tissue. This causes increased functional activity of β3-adrenoreceptors and fewer insulin receptors in visceral adipocytes, which leads to more intensive metabolism of lipids in visceral adipose tissue than in other fat depots (Hall et al., 2010). Also, it is easier for free fatty acids to enter into the liver because the portal vein passes through the visceral adipose tissue. Excessive intake of free fatty acids by liver cells results in decreased insulin sensitivity and the development of insulin resistance and systemic hyperinsulinemia, which contributes to the development of peripheral insulin resistance (Odegaard & Chawla, 2013). Furthermore, both insulin resistance and excess free fatty acid levels cause impaired lipid metabolism and the development of atherogenic dyslipidemia (Kovalik et al., 2011).

Health benefits of physical activity

There are several health benefits associated with being physically active. Regular physical activity reduces the risk of numerous chronic diseases such as cardiovascular disease, stroke, type 2 diabetes, cancer, obesity, and arthritis (Blair & Morris, 2009). More specifically, someone who is physically active can improve his or her body composition, blood pressure, lipid profile, and glucose homeostasis and insulin sensitivity. There is also a decreased risk of osteoporosis, sarcopenia, mortality, and age-related morbidity in older adults (Blair & Morris, 2009). Warburton, Nicol and Bredin (2006) concluded that observational studies provide strong evidence that living a physically active lifestyle and maintaining a high fitness level are related to a reduced risk of premature death from any cause. There is also a dose-response relationship with exercise. That is, an individual who participates in a high level of physical activity and fitness is at a lower risk of premature death.

Floorball and similar sports

Team sports such as floorball, hockey, and soccer require participants to complete short sprints, separated by periods of rest or low to moderate activity. There have been very few studies conducted related to floorball. Tervo and Nordstrom (2014) completed a comprehensive review related to scientific research on floorball. They reviewed full articles that contained original data and were published in English in peer-reviewed journals. Seventy-five articles were screened but only 19 met the criteria. Most of the articles published were related to sports medicine. The purpose of one study was to develop a new test to estimate maximal strength (Rontu, Hannula, Leskinen, Linnamo, & Salmi, 2010). Tervo and Nordstrom (2014) mention that there has been no research related to children or adolescents performing floorball. They concluded that there is a lack of scientific knowledge related to floorball. More studies are needed, as the popularity of floorball is increasing and the sport has developed into one of the fastest growing sports in the world.

Nyberg et al. (2014) studied the physiological effects of playing floorball for 12 weeks. The participants were 13 premenopausal and 10 recently postmenopausal women between the ages of 48 and 51 years. The exercise sessions were conducted twice a week and included 30 min of technical and tactical floorball exercises and 30 min of game play with 4–6 min intervals at greater than 85% of maximum heart rate (HR_{max}). Recovery periods of 1–3 min were also part of the sessions. The VO_2max was measured using a treadmill and it improved significantly with both groups. It was 4.6 ± 1.8% higher with premenopausal women (34.6 ± 1.9 vs. 36.45 ± 2.2 ml/kg/min) and 5.5 ± 1.6% higher with postmenopausal women (31.9 ± 1.6 vs. 33.5 ± 1.8 ml/kg/min) after the exercise program. Body fat, measured using dual-energy X-ray absorptiometry (DEXA), decreased significantly in postmenopausal women (39.2 ± 1.8 to 37.4 ± 2.0 %). Postmenopausal women had a higher diastolic blood pressure (DBP) at the beginning of the study compared to premenopausal women (79 ± 3 vs. 71± 3 mmHg) and playing floorball significantly lowered the response in both groups (3.9 ± 1.7 and 2.8 ± 1.3 mmHg in postmenopausal and premenopausal women, respectively). Finally, there was a significant increase in HDL-C in postmenopausal women (2.11 to 2.25 mmol/l). Nyberg et al. (2014) concluded that high-intensity exercise training such as floorball is an effective and time-saving way to decrease cardiovascular disease risk in middle-aged women.

Seidelin, Nyberg, Piil, Jorgensen, Hellsten, and Bangsbo (2017) investigated the effect of playing floorball on musculoskeletal and metabolic health in postmenopausal (PM) and premenopausal (PRM) women. Eighteen PM (age 52 ± 1 years) and 12 PRM (age 48 ± 1 years) women took part in the study, and met twice a week for 12 weeks. The participants warmed up for 30 min performing low-intensity floorball drills followed by playing floorball for 30 min. The games were played in 4- to 6-min intervals followed by a 1–3 min recovery period. The participants were separated into five groups and played 3-on-3 games on a 12 x 20-m court. Percent body fat, measured using DEXA, decreased significantly from 38.6 ± 1.7 to 36.4 ± 1.9% in PM women but did not change in PRM women. There were no significant changes in BMI in either group. Maximal oxygen uptake increased significantly in both PM and PRM groups (2311 ± 97 vs. 2411 ± 101 ml/min and 2222 ± 134 vs. 2324 ± 124 ml/min, respectively). The participants' heart rates were also measured during the sessions and reached more than 85% of HR_{max} for more than 20% of the time. The authors concluded that playing floorball twice a week is an effective method in improving body composition and aerobic fitness in PM and PRM women.

Vorup, Pedersen, Melcher, Dreier, and Bangsbo (2017) studied the effects of floorball in the elderly adults. Blood lipids, muscle strength, body composition, and functional capacity were measured. Thirty-nine recreationally active men between the ages of 65-76 years participated in the study. They were randomly assigned to either a floorball group (FG) or petanque group (PG). Both of the groups played 1 hr twice a week for 12 weeks. Average heart rate was 80% of HR_{max} in the FG and 57% of HR_{max} in the PG. There was also a significant decrease in low-density lipoprotein (LDL-C) (11%), triglycerides (8%), total fat (5%), visceral fat (14%), and insulin resistance (18%) in the FG, but not in the PG. Vorup et al. (2017) concluded that floorball can be a great way to increase health and fitness even in the elderly.

Knoepfli-Lenzin et al. (2010) compared the health effects of soccer (S), running (R), and no additional activity (C). Forty-seven active men between the ages of 25 and 45 years with mild hypertension participated in the 12-week study. The S and R groups exercised for 1 hr, 2.4 times per week on average. There was a decrease in both systolic blood pressure (SBP) and DBP in all three groups, but DBP decreased to a greater extent in the S group. The S group, but not the R group, reduced DBP significantly after the intervention compared to the C group. The S and R groups also significantly decreased their fat mass. In addition, there was an increase in maximal SV in the S group (+13.1%) and in the R group (+10.1%) and a decrease was observed in the C group (−4.9%). Total cholesterol decreased in the S group (5.8 to 5.5 mmol/L); however, it was unchanged in R and C groups. Maximal oxygen uptake increased 9% in the S group and 12% in the R group. Knoepfli-Lenzin et al. (2010) concluded that playing soccer, a high-intensity intermittent sport, can decrease blood pressure, percent body fat, SV, and resting heart rate, and increase VO_2max. These benefits can be equal to or greater than that of someone performing continuous exercise at the same intensity.

High-intensity interval training

Higgins, Baker, Evans, Adams, and Cobbold (2015) investigated different cardio-metabolic risk factors in 23 young, healthy adults. The participants were separated into control and test groups. The high-intensity interval training (HIIT) group cycled three times per week for 6 weeks. They completed a 5-min warm-up followed by 3 x 1 min maximum intensity cycling at maximal aerobic power. They also completed 2 min of low-intensity exercise between the intervals and a 3-min cool down. Body composition, glucose tolerance, VO_2max, blood pressure (BP), cholesterol, and triglycerides (TG) were measured before and after the study. Some participants responded favorable to HIIT. Maximal oxygen consumption increased significantly from 45.4 to 56.9 ml/min/kg with these participants. There was no statistically significant effect of HIIT on SBP or DBP. However, among those participants who were classified as responders (i.e., having a beneficial change greater than 2 standard errors of the mean from baseline), SBP decreased significantly from 127 to 116 mmHg and DBP from 72 to 57 mmHg with HIIT. Higgins et al. (2015) did not mention how many participants were responders with regard to SBP measurements. There were only 3 of 11 in the responders group for DBP, making the statistical analysis underpowered. The participants in this study were young and healthy so this might have been the cause for the results. They also noticed a beneficial but not significant change in blood lipid and glucose concentrations with HIIT. The authors concluded that HIIT is an effective way to improve cardiovascular health.

Hazell, Hamilton, Olver, and Lemon (2014) investigated whether high intensity running can alter body composition, waist circumference, VO_2max, peak running speed, LDL-C, high-density lipoprotein (HDL-C), total cholesterol, and TG. Fifteen healthy women with an average age of 22.9 ± 3.6 years completed the 6-week study. The participants ran four to six, 30 s "all-out" sprints and rested 4 min between the intervals. The exercise was performed three times per week. Body fat percentage decreased significantly from 24.7 ± 4.9 to 23.0 ± 4.6% and waist circumference also decreased significantly from 80.1 ± 4.2 to 77.3 ± 4.4 cm. Maximal oxygen consumption increased significantly from 46 ± 5 to 50 ± 6 ml/kg/min. This study indicates that HIIT is a time-efficient way for improving body composition and cardiovascular fitness.

High-intensity interval training vs. steady state exercise

High-intensity interval training has resulted in greater aerobic and cardiovascular adaptations than training that is done at low or moderate levels in both healthy subjects (Lee, Sesso, Oguma & Paffenbarger, 2003) and patients with cardiovascular disease (Wisloff et al., 2007).

Hoydal and Hareide (2016) conducted an 8-week study with 22 male and female recreational runners between the ages of 23 and 30 years. The participants were randomly assigned to either a high-intensity interval training (ITG) or a low-intensity, longer-lasting training (CTG) group. The participants in the CTG group ran for 75 min three times per week and maintained an average heart rate of 75% of HR_{max}. Total training time for this group was 3 h and 45 min per week. The ITG group performed 4 x 4 min interval training runs three times per week at 90-95% of HR_{max}, interspersed with 3 min of exercise at 70% HR_{max}. Total training time for the ITG group was 1 h and 54 min per week. Maximal oxygen uptake improved significantly more in the ITG group (11.3 ± 4.1%) compared to the CTG group (4.7 ± 3.3%) although the ITG group spent less time exercising. The investigators concluded that HIIT can be more effective and time efficient in improving cardiorespiratory fitness compared to SSE.

Foster et al. (2015) compared two different HIIT protocols with SSE. Twenty-three males and 42 females participated in this 8-week study. The participants cycled three times a week and did either SSE for 20 min at 90% of ventilatory threshold, eight intervals of 20 s at 170% VO_2max with 10 s rest between intervals, or 13 sets of 30 s at 100% of peak VO_2max with 60 s of recovery between intervals. Maximal oxygen uptake increased significantly in all groups (18-19 ± 2.3%), and there were no significant differences between groups. The enjoyment of the training program was also measured. The results indicated that after 8 weeks, the postexercise enjoyment was significantly lower in the most intense training group compared to SSE group. There was also a progressively declining level of enjoyment in all groups during the study. The authors concluded that HIIT protocols, while time efficient, are not superior to conventional exercise training protocols in sedentary young adults.

A study conducted by Gillen et al. (2016) compared sprint interval training (SIT) to traditional moderate-intensity continuous training (MICT). The participants were 19 sedentary men (27 ± 8 years; BMI = 26 ± 6 kg/m^2) and they were divided into two groups. The SIT group performed three 20-sec “all out sprints” on a cycle ergometer interspersed with 2 min of low intensity cycling. The MICT group cycled 45 min at ~70% of their maximal heart rate. The participants followed this program three times a week for 12 weeks. Both groups increased their VO_2max by 19% (SIT: 32 ± 7 to 38 ± 8 ml/kg/min; MICT: 34 ± 6 to 40 ± 8 ml/kg/min). They also noticed a significant increase in insulin sensitivity and skeletal muscle mitochondrial content and the increase was similar between the groups. This study indicated that SIT improved indices of cardiometabolic health to the same extent as MICT. However, the exercise volume and time commitment was five times lower with the SIT group.

High-intensity interval training can be used to increase total daily caloric expenditure and make positive changes with body composition. Greer, Sirithienthad, Moffatt, Marcello, and Panton (2015) investigated the effects of exercise mode and intensity on excess postexercise oxygen consumption (EPOC). Ten low- to moderately-active men performed three nonrandomized bouts of exercise separated by 7 days. The exercises were resistance training (RT), SSE, and HIIT. The total energy expenditure, rate of energy expenditure, and duration was not different among trials. At 21 hr postexercise, resting metabolic rate was significantly higher after the RT trial (3.7 ± 0.51 ml/kg/min) and HIIT trial (3.5 ± 0.39 ml/kg/min) compared with the SSE trial (3.2 ± 0.38 ml/kg/min). The authors concluded that both RT and HIIT may be more effective at increasing total daily caloric expenditure than SSE exercise.

Buchan et al. (2011) examined the effects of performing exercise at different intensities three times a week for 7 weeks on components of physical fitness and CVD risk factors. Forty-seven boys and 10 girls, (16.4 ± 0.7 years) were divided into a moderate, high-intensity, or a control group. Participants in the high-intensity group completed 30 s maximal sprints separated by 20-30 s rests. This protocol was repeated 4-6 times during the study. Participants in the moderate intensity group ran at an intensity of 70% VO_2max for 20 min. There was no significant difference in BMI or the waist-to-hip ratio between the two exercise groups. Percentage body fat decreased significantly in the moderate exercise group (19.73 ± 8.6 vs. 17.64 ± 6.54 %), but there was not a significant difference between groups. There was a significant improvement in cardiorespiratory fitness, muscular fitness, speed/agility and SBP in the HIIT group. Cardiorespiratory fitness was measured using the 20-m multistage fitness test. The authors noted that the improvements in physical fitness occurred in the HIIT participants in only 15% of the exercise time compared to the moderate intensity group. This study demonstrated that HIIT is a time efficient way of improving components of health in youth.

Nybo et al. (2010) completed a 12-week study comparing the effects of intense interval training and prolonged exercise on health. The participants were 36 physically inactive men with an average age of 31 years. The interval group completed 20 min of running twice a week. It included 5 min of warm-up followed by five intervals of 2 min of running above 95% HR_{max} at the end of the run. The prolonged training group ran 1 hr, an average of 2.5 times per week with the intensity of 80% of HR_{max}. The total exercise time was 480 min for the interval group and 1800 min for the prolonged exercise group. There was a significant improvement in VO_2max between the groups with the interval group improving more than the prolonged training group (14 ± 2 vs. 7 ± 2%). There was also a significant decrease in glucose tolerance with both groups (.85 ± 0.9 mM on average), but there was no difference between the groups. Interval training was less effective than prolonged training at lowering resting heart rate (3 ± 2 vs. 6 ± 2 bpm), fat percentage (0.5 ± 1.6 vs. 1.7 ± 1.6 %), and reducing the ratio between total and HDL-C plasma cholesterol (0.08 ± 0.1 vs. 0.50 ± 0.3 mM).

Ciolac et al. (2010) used 44 healthy women (25.0 ± 4.4 years) to study the effects of HIIT and SSE. The HIIT group walked or ran 1 min at 80-90% of VO_2max followed by 2 min of walking at 50-60% of VO_2max. The SSE group walked at 60-70% of VO_2max. Both groups exercised for 40 min three times per week for 16 weeks. High-intensity interval training was not significantly different between the groups. Both of the groups increased their VO_2max but the HIIT group had a significantly larger increase (15.8 ± 6.3% vs. 8.0 ± 6.1%). This study showed that exercise intensity is an important factor in improving cardiorespiratory fitness.

Helgerud et al. (2007) compared HIIT with moderate intensity, continuous training. Forty healthy male participants were randomly assigned to either long, slow distance, training at the lactate threshold, 15/15 interval running (15 s of near maximal running followed by 15 s of rest), or 4 x 4 min of interval running (4 x 4 min of near maximal running separated by 3 min of rest) group. The participants ran three times per week. Participants' VO_2max, SV, blood volume, lactate threshold, and running economy were assessed. High-intensity interval training resulted in significant increases in VO_2max compared with moderate training (5.0 ± 2.8 vs. 1.2 ± 3.3 ml/kg/min). Stroke volume increased significantly as well (15 ± 12 vs. 1.2 ± 9.5 ml/beat). The authors concluded that the most effective way to improve VO_2max is to perform HIIT.

Edge, Bishop, Goodman, and Dawson (2005) studied the effects of HIIT and SSE on 20 young (19 ± 1 years), female participants. Both groups cycled three times a week for 5 weeks. The HIIT group performed 6–10, 2-min intervals at 120–140% lactate threshold (LT), separated by 1-min recovery periods. The SSE group cycled continuously for 20–30 min at 80–95% of their LT. The investigators were looking at changes in repeated sprint ability (5 x 6 s sprints every 30 s) and muscle metabolism. Muscle biopsies were taken from the vastus lateralis. They also focused on VO_2max and LT. A significant increase in VO_2max (10-12%) and LT (8-10%) was observed with both groups, but they did not find a significant difference between groups. A significantly greater increase was observed in repeated sprint ability in the HIIT group (13 vs. 8.5%). They did not find significant differences in muscle metabolites between groups. The authors concluded that HIIT results in greater improvements in repeated sprint ability than SSE. Since they did not observe a significant difference in VO_2max and muscle metabolism, this difference is not explained by differences in aerobic fitness or metabolite accumulation. Further studies are needed to explain the greater improvement in spring ability in the HIIT group.

It is also important to consider the enjoyment of HIIT. Past studies on enjoyment of HIIT show conflicting findings (Vella, Taylor, & Drummer, 2017). Thum, Parsons, Whittle, and Astorino (2017) state that HIIT might be less tolerable with some people because HIIT is often accompanied by shortness of breath, leg pain, and considerable fatigue. However, HIIT is well tolerated even with participants who have low initial fitness level (Bartlett et al., 2011). In fact, some participants may enjoy HIIT more than SSE (Thum et al., 2017). Greater postexercise feelings of enjoyment with HIIT are due to varied activity, which seems more enjoyable than activity completed at the same intensity throughout the exercise session (Wisloff et al., 2007; Tjonna et al., 2008).

In a study conducted by Thum et al. (2017), the researchers investigated differences in enjoyment between SSE and HIIT using the PACES. The participants were 12 recreationally active men and women with an average age of 29.5 ± 10.7 years. They completed two cycling sessions separated by 2 to 7 days. High-intensity interval training consisted of eight, 1 min trials at 85% maximal workload with 1 min of cycling at 25% of maximal workload between trials. Steady state exercise included cycling 20 min at 45% of maximal workload. The participants enjoyed HIIT more (103.8 ± 9.4) compared to SSE (84.2 ± 19.1; $p = 0.013$). Moreover, 11 of 12 participants preferred HIIT compared to SSE. Thum et al. (2017) concluded that although HIIT is a more intense type of exercise than SSE, participants enjoyed it more. High-intensity interval training is a time efficient and enjoyable way to build fitness and should be part of an exercise recommendation given to healthy individuals.

Vella et al. (2017) completed a study with 17 overweight and obese adults. The study lasted 8 weeks and included both HIIT and SSE groups. Participants completed 30 min of exercise four times a week. The purpose of the study was to measure enjoyment and cardiometabolic outcomes. Exercise enjoyment was measured by using the Physical Activity Enjoyment Scale. There was no difference related to enjoyment between the HIIT and SSE groups (100.1 vs. 100.3, respectively). There was significantly greater increase in VO_2max in HIIT group compared to the SSE group (2.6 ± 1.9 vs. 0.4 ± 1.5 ml/kg/min, respectively). The authors concluded that HIIT can be an enjoyable way to exercise, and is an effective way to increase cardiovascular fitness.

Martinez, Kilpatrick, Salomon, Jung, and Little (2015) investigated the psychological effects of HIIT. The participants were 20 physically inactive and overweight and obese adults. They performed four types of trials: one 20-min heavy, continuous exercise trial and three HIIT trials lasting 24 min each. The HIIT trials included a rest-to-work ratio of 1:1 and lasted 30, 60, and 120 s. The enjoyment of the exercise was measured with the 7-point Exercise Enjoyment Scale. Enjoyment declined significantly from 3.7 ± 1.1 to 2.4 ± 1.3 in the 120-s condition and from 3.6 ± 1.4 to 3.0 ± 1.9 in the heavy continuous condition. When comparing the postexercise enjoyment, it was significantly higher in the 60-s condition than in the 120-s condition and heavy continuous condition. Short intervals may therefore be more enjoyable than the longer intervals or continuous exercise.

Bartlett et al. (2011) used eight recreational active men to objectively quantify ratings of perceived enjoyment using the Physical Activity Enjoyment Scale. The participants performed two running protocols that included HIIT and SSE. The exercise sessions were done 7 days apart. The HIIT consisted of six, 3-min running intervals at 90% of VO_2max separated by six, 3-min recovery periods at 50% of VO_2max. The SSE was done at 70% of VO_2max for 50 min. The investigators found that the HIIT session had a significantly higher rating of perceived enjoyment after exercise compared to the SSE session (88 ± 6 vs. 61 ± 12), although the RPE was higher in the HIIT session (14 ± 1 vs. 13 ± 1). The conclusion of the study was that there was a greater enjoyment with HIIT.

High-intensity interval training and adolescents

Armstrong (2016) reviewed studies focusing on aerobic training in children and adolescents. The author noted that most studies related to aerobic training with this population have been conducted using constant intensity exercise training (CIET). Only a few studies have been conducted using HIIT to increase aerobic fitness. The author recommends that more studies should be done with healthy young participants and these studies should compare the effects of CIET and HIIT.

Costigan, Eather, Plotnikoff, Taaffe and Lubans (2015) used a systematic review and meta-analysis to evaluate the effects of HIIT on healthy adolescents. Studies included those that used 13-18-year-olds as participants, investigated health-related fitness outcomes, lasted more than 4 weeks, used a control or CIET group, and included a group that performed high-intensity activity. Only eight studies met their criteria. They noted that none of the studies used a comparison group who performed appropriate CIET. The intervention effect from a random effects model was statistically significant for cardiorespiratory fitness (unstandardized mean difference (*MD*) = 2.6 ml/kg/min, $p < .001$) and also for body fat percentage (*MD* = −1.6%, $p = .006$). The authors concluded that HIIT is a time-efficient training method to increase cardiorespiratory fitness and it can also be used to improve body composition.

A narrative literature review by Logan, Harris, Duncan, and Schofield (2014) included studies focusing on HIIT and metabolic health. They also concluded that there is limited research with adolescents. The authors emphasized that it is crucial to develop new ways to improve cardiometabolic health in this population because of the rising costs of chronic disease. The authors concluded that cardiovascular fitness, insulin sensitivity, adiponectin, fasting plasma insulin, and triacylglycerol were improved to a greater extent with HIIT compared to SSE. However, the data does not appear to support this conclusion. Out of the 11 studies they reviewed, only four compared HIIT with SEE. Future research studies should focus on identifying different HIIT protocols and show differences in cardiometabolic measures with regard to HIIT, CIET, or some control group. Perceived enjoyment and exercise adherence should also be investigated.

Crisp, Fournier, Licari, Braham, and Guelfi (2012) studied adding sprints to continuous exercise. The participants were nine overweight and nine normal weight boys ages 8-12 years. Measurements that were taken included body anthropometrics, the intensity of exercise that maximized fat oxidation, VO_2max, resting metabolic rate, and enjoyment of exercise. The participants completed 30 min of either continuous cycling at an intensity that maximized fat oxidation or sprint interval exercise. The authors plotted fat oxidation rate versus exercise intensity, expressed as a percentage of VO_2, to determine the intensity that corresponded to maximal fat oxidation. The sprint interval exercise involved 4 s maximal sprints every 2 min. There were no differences between groups and protocols with fat oxidation rate. The sprint group expended 19% more kilocalories and the participants stated that they preferred sprint exercise over continuous cycling. The authors concluded that sprint interval exercise should be used when designing programs for young people.

Barker, Day, Smith, Bond, and Williams (2014) investigated 2 weeks of HIIT on cardiovascular fitness, BP, BMI, and fat oxidation in healthy adolescent boys. Ten adolescent boys ages 14-16 years completed four to seven all out 30-s sprints followed by 4-min rest. They completed six total sessions during the 2-week period. There was a beneficial effect on parameters of aerobic function and lipid oxidation, but not on blood pressure and BMI. Maximal oxygen uptake improved by 2.7 ± 8.3 ml/kg/min. This study demonstrated that even a short duration HIIT program can yield positive changes in health.

Tjonna et al. (2009) examined the effects of aerobic interval training (AIT) on cardiovascular risk factors in overweight and obese adolescents. There were 54 participants with mean age of 14 ± 0.3 years who were separated to an AIT group or a multidisciplinary approach group (MTG). The AIT group walked or ran on a treadmill twice a week for 3 months. They exercised for 4 min at 90% of HR_{max} followed by 3 min of exercise at 70% of HR_{max}. This sequence was repeated four times. After 3 months of training, the participants were encouraged to perform at least two interval sessions per week on their own. Participants were tested again after 12 months. The MTG met twice a month for 12 months to receive advice about exercise, dietary and psychological topics. Measurements of body fat, BMI, VO_2max, BP and blood analysis were performed after 3 months and again after 12 months. After 3 months of high-intensity AIT, several cardiovascular risk factors, including fat percentage, BMI, HDL-C, mean arterial pressure (MAP), fasting glucose and VO_2max were improved when compared to the MTG. More specifically, there was a significant improvement in fat percentage (2 ± 2.0%), MAP (6.2 ± 5.2 mmHg), VO_2max (18.7 ± 3.5 ml/kg/min), and fasting glucose (0.3 ± 0.28 mmol/l) after 12 months of AIT.

In summary, there have been very few studies conducted related to floorball. Previous studies have shown that high intensity exercise training such as floorball can be an efficient way to increase cardiovascular fitness and body composition in adults (Nyberg et al., 2014; Seidelin et al., 2017). There have been no studies investigating the effects of floorball in adolescents or young adults. A few studies have shown that HIIT can be an effective way of improving cardiovascular fitness and body composition in adolescents (Costigan et al., 2015; Tjonna et al., 2009).

CHAPTER III

METHODS

Participants

Thirty-one healthy, sedentary adolescents and young adults with an average age of 19.1 ± 1.3 years and with a BMI of 25.7 ± 3.3 kg/m^2 participated in this study. All participants were required to sign a written informed consent form approved by the Texas Woman's University Institutional Review Board (see Appendix C) and permission from parents was also required if they were under 18. The participants were not on any medication that might have affected the cardiovascular and metabolic responses and they did not have any diagnosed cardiovascular, pulmonary, metabolic, or musculoskeletal condition. Exclusion criteria also included current smokers (within the past year) and adolescents who participated in organized sports. The Physical Activity Readiness Questionnaire+ (PAR-Q+) was completed before the study to determine the health status of the participants. If they answered yes to one or more questions on the PAR-Q+, they were not allowed to participate. The participants were recruited from a university in the north Texas area.

Pilot Study

Ten males and six females with a mean age of 22.2 ± 6.7 years participated in a 7-week pilot study. The participants played floorball twice a week for 40 min. Heart rate, lactate (La), and RPE were measured during the play at Weeks 1, 4, and 7, and the participants also completed a VO_2max test at Weeks 0 and 7. The average heart rate

(HR_{ave}), peak HR, La, and RPE were 159 ± 18 bpm, 186 ± 15 bpm, 7.3 ± 4.2 mmol/L, and 13 ± 3, respectively during the 7-week study. Maximal oxygen consumption increased significantly from 36.6 ± 9.0 to 38.4 ± 10.1 ml/kg/min.

Study Design

The purpose of the study was to compare cardiovascular fitness and body composition measures before and after 7 weeks of floorball versus steady-state exercise in healthy young adults. There were 14 participants assigned to the floorball FRBL group and 17 in the SSE group. The FRBL group completed a 30-min HIIT protocol two times a week. Games were played four-on-four without goalies on a regular size basketball court. The participants played floorball for 2 min followed by 1 min of rest. Total playing time during the 30 min session was 20 min. The participants in the FRBL group were classified as beginners with less than one year of playing experience. The participants in both groups were instructed to maintain their habitual lifestyle and their normal diet during the study.

The SSE group exercised on a treadmill for 30 min at 60-85% of HRR two times a week. The speed that corresponded with 60-85% of HRR was selected with the treadmill grade being 0%. Heart rate was monitored throughout the exercise session. Both of the exercise groups also completed a 5-min warm-up and cool down. Heart rate was measured with the Polar HR monitor (Polar Electro Oy, Kempele, Finland) with both average and peak HR recorded. Rating of perceived exertion was measured using the Borg scale. An iPad (Apple Inc, Cupertino, CA) and Polar GoFit App (Polar Electro Oy, Kempele, Finland) were used to monitor the intensity in the FRBL group and feedback was provided to the participants during rest periods. For the FRBL group, HR and RPE were recorded every 3 min. This occurred at the beginning of the rest period immediately after the 2-min exercise interval. For the SSE group, HR was monitored continuously and recorded at 15 and 30 min, and RPE was assessed also at 15 and 30 min. Physical activity enjoyment (PAE) was measured in both groups immediately after each exercise session using the 7-point bipolar PACES. This scale has been validated by Kendzierski and DeCarlo (1991).

Maximal oxygen consumption was determined approximately 1 week before the exercise programs started and again two to four days after the end of the study using a graded exercise test on a standard treadmill (Cardiac Science, QuintonT65, Bothell, WA). All participants completed the VO_2max test using a protocol that was similar to the type of training performed. This test was a maximal exercise test where the participants exercised to complete exhaustion as the speed of the treadmill increased by 1 mph every 2 min. The speed on the first stage was between 3-4 mph and the grade stayed at 3% throughout the test. Respiratory gases were measured using a ParvoMedics TrueOne 2400 cart (ParvoMedics, Salt Lake City, UT). Participants were fitted with a mouthpiece, a 2-way breathing valve (model 2700B; Hans Rudolf, Kansas City, MO), and a nose clip so that gases could be measured. Various criteria have been used to confirm that a maximal effort has been elicited during a graded exercise test. According to Riebe, Ehrman, Liguori, and Magal (2018), a peak RER ≥ 1.10 is the most accurate and objective noninvasive indicator of participant's effort during a graded exercise test. Due to the relatively large error in estimating the HR_{max} from the age-predicted formula, there is little or no support for using it as a criterion for achieving VO_2max (Howley, Bassett & Welch, 1995). Thus, in the absence of a plateau in VO_2 after an increase in workload, in the present study, RER was used as the primary criterion for achievement of VO_2max.

Heart rate, BP and RPE were also measured during the VO_2max test. Heart rates were measured continuously and recorded every 30 s throughout the test, and BP and RPE were measured at the end of each stage. Maximal HR from the graded exercise tests was used when determining target heart rates for the SSE group. The experiment started approximately one week after the fitness testing to give the participants enough time to recover.

Body composition was also measured before and after the 7-week training protocol. Body composition was assessed using BMI, waist circumference, and percent body fat. The same investigator performed all of these measures. Height and body mass were measured using standard height and weight scale, and BMI was calculated by dividing the body mass in kilograms by the height in meters squared. The participants were wearing their workout clothing, but no shoes, and these measurements were done after the participant used the restroom. Waist circumference was measured around the smallest part of the waist while standing relaxed using a Gulick II tape measure (Gays Mills, WI), and percent body fat using skinfold calipers (Beta Technology Incorporated, Cambridge, Massachusetts). The Jackson and Pollock three-site skinfold formula (Jackson & Pollock, 1978) was applied to determine body density. The formula to calculate body density for males is 1.10938 – (0.0008267 x sum of skinfolds) + (0.0000016 x square of the sum of skinfolds) – (0.0002574 x age) and for females

1.0994921 – (0.0009929 x sum of skinfolds) + (0.0000023 x square of the sum of skinfolds) – (0.0001392 x age). The sites included the chest, abdomen, and thigh for men and triceps, suprailiac, and thigh for women. Duplicate measurements were taken of all the skinfold sites. The Siri formula (Siri, 1956) was used to convert body densities to percent body fat. The formula reads as follows: Body Fat Percentage (%) = (495 / Body Density) – 450.

Statistical Analysis

The sample size calculations were based on the number of participants needed to detect statistically significant changes in cardiovascular fitness and body composition. Sample size was calculated based on sample size analysis performed on G-Power (Erdfelder, Faul & Buchner, 1996) and an effect size of 0.5. The effect size was chosen based upon the pilot study. With β set at 0.80 and α at 0.05, 14 participants per group were needed.

All analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL). A two-way mixed design MANOVA was used to compare VO_2max, BMI, waist circumference, and body fat values between the groups (FRBL, SSE) at the two data collection points. Effect sizes (partial eta squared) for these variables were also calculated. Average HR, peak HR, RPE, and PAE during the 7 weeks were calculated and a two-way mixed design MANOVA was used to test differences between FRBL and SSE groups. If a significant interaction was found, a simple effects analysis with a Bonferroni adjustment was performed. In the absence of an interaction, significant main effect differences were evaluated using a Bonferroni post hoc test to determine where the differences occurred across time. The alpha level for all tests was set at .05.

CHAPTER IV

RESULTS

The present study was conducted to examine the cardiovascular fitness and body composition measures before and after 7 weeks of floorball versus SSE in healthy adolescents. In addition to this, perceived enjoyment of exercise was also analyzed.

Description of the Participants

Initially, 35 participants entered the study. Seven participants were recruited from a floorball class, and they were assigned to the FRBL group. The remaining 28 volunteers were randomly assigned to either the FRBL (9 participants) or the SSE (19 participants) group. Three participants dropped out of the study due to injuries and one due to time constraints. Two participants in the FRBL group had a mild ankle sprain while playing and one participant in the SSE group had a non-study related injury. Two of them were able to complete the posttest body composition assessments. The final sample for the study consisted of 31 participants (FRBL group: n = 14, SSE group: n = 17). There were 17 male and 14 female participants. There were six females in the FRBL group and eight in the SSE group. Of the participants who completed the study, the overall adherence to the training program for the entire sample was 90.8 ± 9.6% (FRBL group: 86.7 ± 10.8%, SSE group: 94.1 ± 7.2%).

At baseline, there were no significant differences in height, weight, body composition measures, or VO_2max between the FRBL and SSE groups. The age was significantly different between groups (FRBL group: 19.9 ± 1.8 years vs. SSE group:

18.5 ± 0.6 years, p = .032). The means and standard deviations for height, weight, BMI, waist circumference, body fat, and VO_2max for both groups are presented in Table 1. Baseline BMI (FRBL group: 25.2 ± 3.9 kg/m^2 vs. SSE group: 26.0 ± 2.9 kg/m^2) and VO_2max (FRBL group: 38.2 ± 7.9 ml/kg/min vs. SSE group: 37.7 ± 7.5 ml/kg/min) were similar between the two groups. These values indicate that the participants were overweight and had fair cardiorespiratory fitness levels at the beginning of the study (Riebe, Ehrman, Liguori, & Magal, 2018).

Table 1
Descriptive Data for Participants Before the Intervention.

Variable	**FRBL (*n* = 14)**	**SSE (*n* = 17)**
Age (years)*	19.9 (1.8)	18.5 (0.6)
Height (cm)	169.8 (9.2)	169.4 (9.9)
Weight (kg)	73.1 (14.1)	75.5 (14.1)
BMI (kg/m^2)	25.2 (3.9)	26.0 (2.9)
Waist Circumference (cm)	80.5 (9.4)	81.6 (10.2)
Body Fat (%)	24.9 (7.7)	24.0 (6.3)
VO_2max (L/min)	2.8 (0.6)	2.9 (0.9)
VO_2max (ml/kg/min)	38.2 (7.9)	37.7 (7.5)

Note. Mean (*SD*) baseline descriptive variables. *Significant difference between groups with p = .032. BMI = body mass index; VO_2max = maximal oxygen consumption; FRBL = floorball; SSE = steady state exercise.

Analyses of Data

Average HR, peak HR, RPE, and enjoyment for the 7 weeks of the study are presented below in Figures 1, 2, 3, and 4 respectively. Initially, a mixed design MANOVA including all four of these variables was planned. However, as there were some missing data points for enjoyment, data from PACES were analyzed separately with mixed design ANOVA (n = 14 and 12 for FRBL and SSE groups, respectively). No significant interaction or main effects were found for enjoyment. With the MANOVA analyses for average HR, peak HR, and RPE, a significant multivariate interaction effect was found (Pillai's trace = 0.897, $p = .007$), as well as a significant multivariate main effect for group (Pillai's trace = 0.759, $p < .001$), but no multivariate main effect for time was found. In the univariate follow-up analysis, there was a significant interaction for RPE ($F = 9.397$, $p < .001$), but not for either HR variable. In the univariate follow-up analysis for the main effect of group, a significant main effect for peak HR was found (main effect means = 188 ± 6 and 175 ± 5 bpm for FRBL and SSE groups, respectively), but not for average HR. For RPE, no changes over the 7 weeks were noted for SSE group, but the FRBL group had significant increases in RPE in Weeks 3-7 as compared to Week 1. Rating of perceived exertion was similar at Week 1 between the two groups, but from Week 2 through Week 7, RPE was significantly higher in the FRBL group than the SSE group.

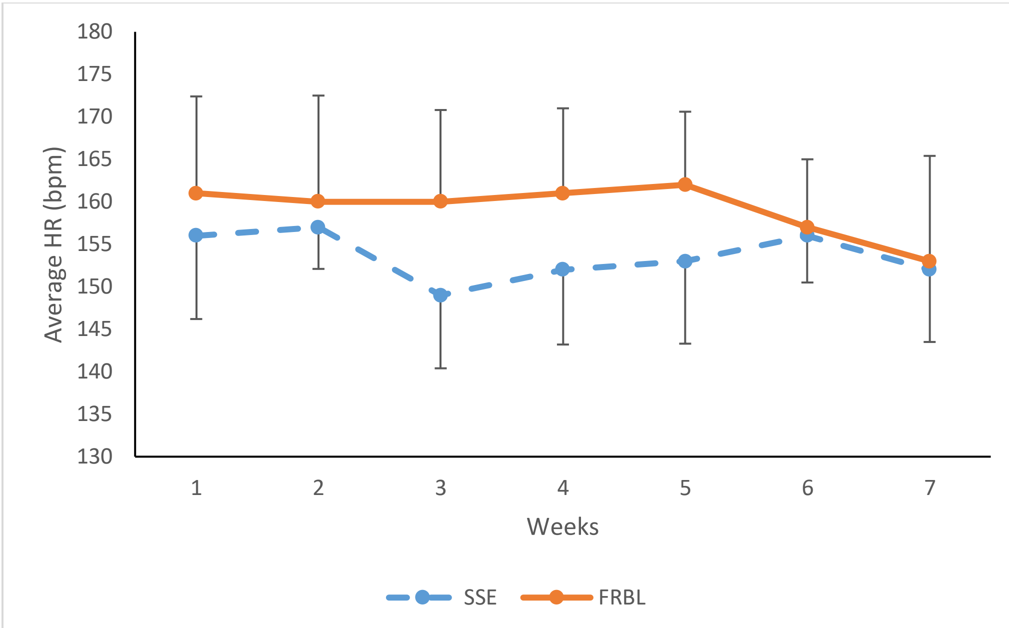

Figure 1. Average HR during the 7 weeks of exercise. FRBL = floorball; SSE = steady state exercise. Values are mean ± *SD*.

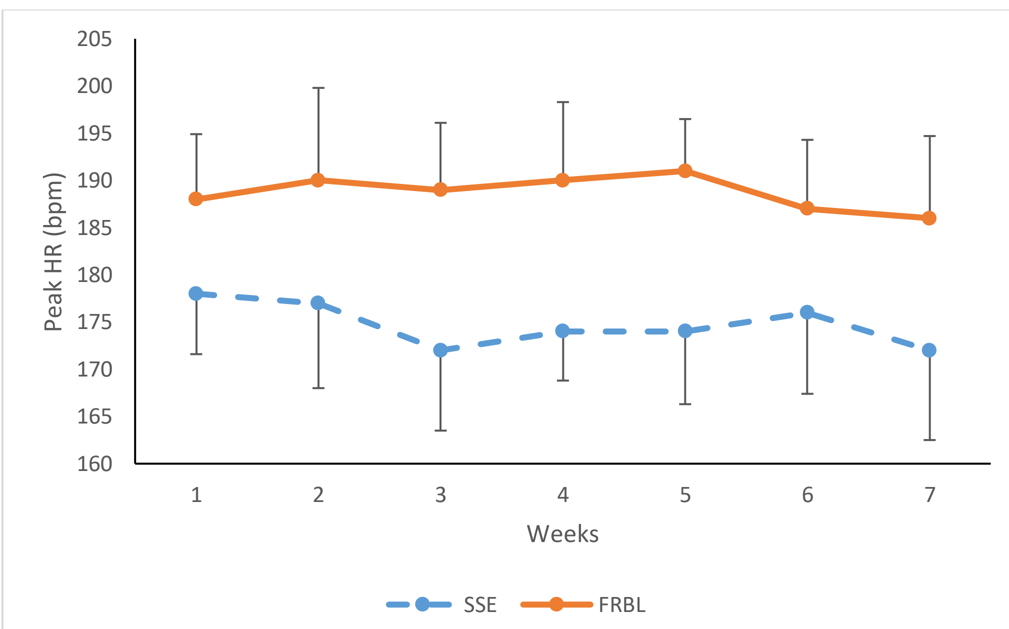

Figure 2. Peak HR during the 7 weeks of exercise. Group main effect was significant ($p < .001$). FRBL = floorball; SSE = steady state exercise. Values are mean ± *SD*.

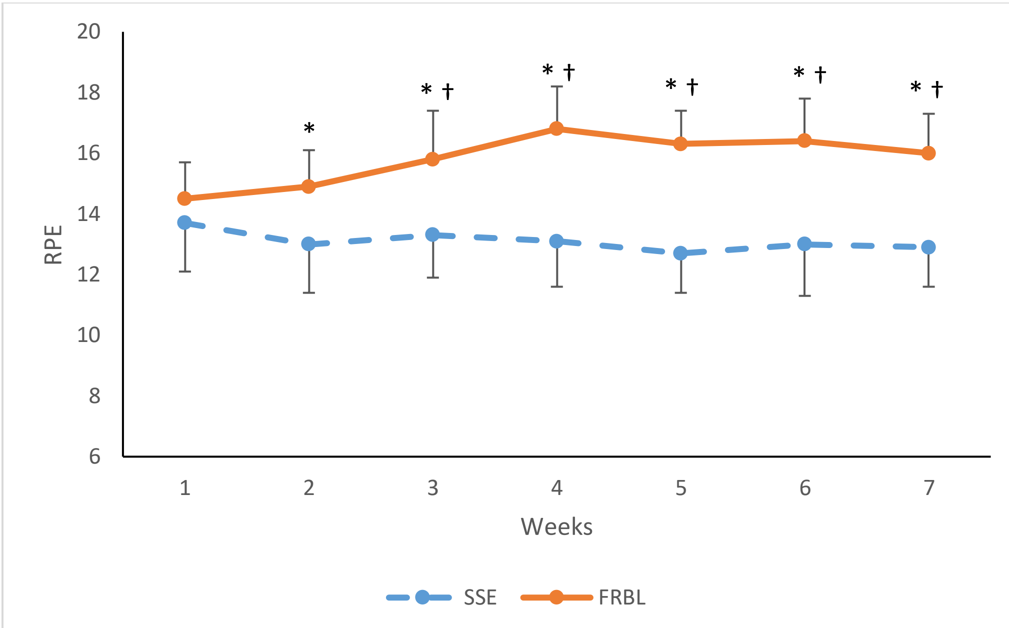

Figure 3. Ratings of perceived exertion during the 7 weeks of exercise. FRBL = floorball; SSE = steady state exercise. Values are mean ± *SD*.
∗ Significant difference between groups ($p < .001$).
† Significant increase in FRBL group compared to Week 1 ($p < .05$).

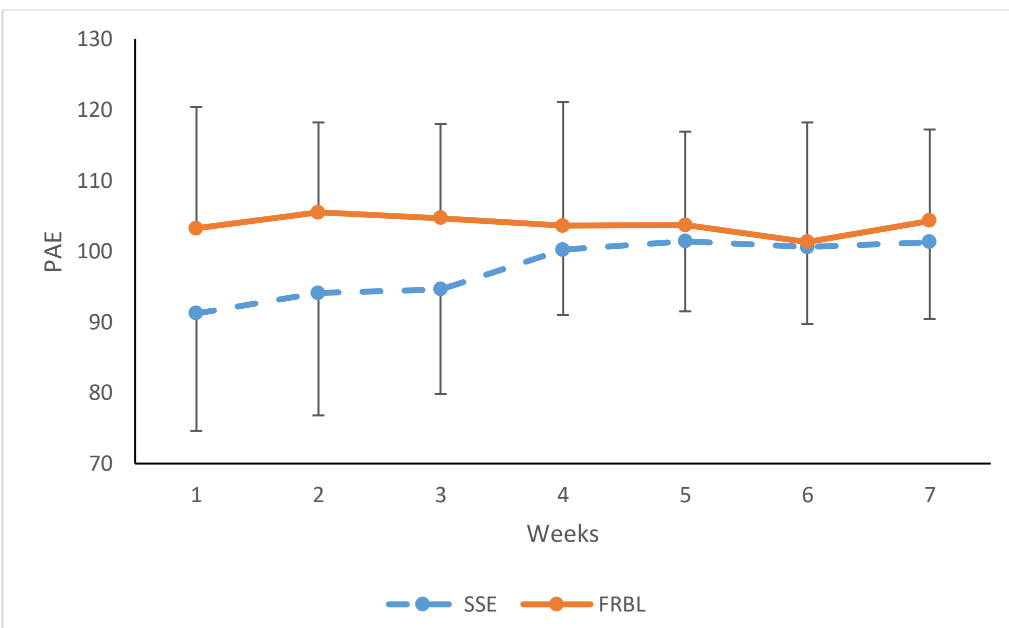

Figure 4. Physical activity enjoyment during the 7 weeks of exercise. FRBL = floorball; SSE = steady state exercise. Values are mean ± *SD*.

Initially, a mixed design MANOVA with VO_2max and the body composition variables was planned. However, VO_2max did not correlate well with the body composition variables, so it was analyzed separately using a mixed design ANOVA. A significant interaction was found for VO_2max, which is shown in Figure 5. Maximal oxygen uptake increased significantly in the FRBL group (pre: 38.2 ± 7.9 ml/kg/min, post: 39.9 ± 7.6 ml/kg/min, p = .012), whereas the SSE group did not increase significantly (pre: 37.7 ± 7.5 ml/kg/min, post: 38.1 ± 7.6 ml/kg/min) following the 7-week intervention (η_2 = .20). It is believed that most of the participants achieved VO_2max during the graded exercise test as during the pretest 29 of 31 achieved an RER ≥ 1.1 and 27 participants achieved that criteria during the posttest (Riebe et al., 2018).

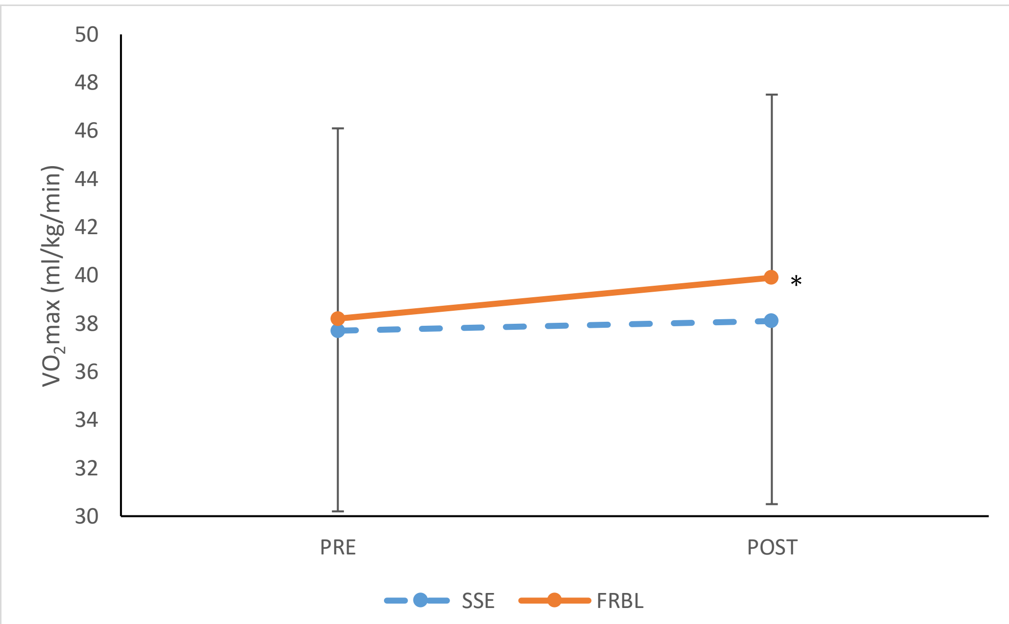

Figure 5. Changes in VO_2max. Values are mean ± *SD*. η_2 = .20
∗ Significant difference from pre to post test (p = .012).

There were no significant interaction or main effects for any of the body composition measures. The summary data for BMI, waist circumference, sum of skinfolds, and body fat are presented below in Table 2.

Table 2

Summary Table: Changes in BMI, Waist Circumference, Body Fat, and Sum of Skinfolds.

	FRBL		**SSE**	
Variable	**Pre**	**Post**	**Pre**	**Post**
***BMI* (kg/m^2)**	25.2 (3.9)	25.4 (3.8)	26.0 (2.9)	26.2 (2.9)
Waist Circumference (cm)	80.5 (9.4)	80.7 (9.0)	81.6 (10.2)	81.8 (10.2)
Body Fat %	24.9 (7.7)	25.0 (7.5)	24.0 (6.3)	24.2 (6.5)
***Sum of Skinfolds* (mm)**	80 (28)	80 (27)	75 (20)	76 (20)

Note. Mean (*SD*). BMI = body mass index, FRBL = floorball; SSE = steady state exercise. η^2 = .001 to .013

CHAPTER V

DISCUSSION OF RESULTS

The purpose of the study was to compare cardiovascular fitness and body composition measures before and after 7 weeks of floorball versus SSE in healthy adolescents and young adults. The study involved 31 male and female participants who were assigned to either the FRBL (n = 14) or the SSE group (n = 17). The participants were cleared for the study based on the PAR-Q+. Maximal oxygen consumption, BMI, waist circumference, and percent body fat were measured in the beginning and at the end of the study. Both of the groups met twice a week for 30 min. The participants in the FRBL group played floorball for 30 min with a 2:1 work to rest ratio. The SSE group exercised for 30 min continuously on a treadmill at 60-85% of HRR two times a week. Heart rate, RPE, and perceived enjoyment of exercise were measured during the study. Mixed design MANOVAs or ANOVAs were used to analyze the data.

Summary of the Findings

Descriptive statistics were performed for all variables examined. Demographical and physiological variables included were height, weight, BMI, waist circumference, sum of skinfolds, body fat percentage, PAE, and VO_2max.

Cardiovascular Fitness, Heart Rate, RPE, and Enjoyment

The primary outcome variable of the study was cardiovascular fitness. A significant increase in VO_2max (p = .012) was observed in the FRBL group, while VO_2max did not improve in the SSE group. There was a significant main effect of group for peak HR (main effect means = 188 ± 6 and 175 ± 5 bpm for FRBL and SSE groups, respectively), but not for average HR. The average HR in the SSE group was 64% of HRR. Rating of perceived exertion was similar at Week 1 between the two groups. From Week 2 through Week 7, RPE was significantly higher in the FRBL group than the SSE group. There was no significant difference in perceived enjoyment of exercise.

Body Composition

The secondary outcome variable of the study was body composition. Body composition was measured through changes in BMI, waist circumference, sum of skinfolds, and percent body fat. There were no significant improvements in any of the body composition measures.

The following decisions were made regarding the previously determined null hypotheses tested at the .05 level of significance.

1. There is no significant difference within each group on VO_2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds over time. RETAINED.

2. There is no significant difference between the groups on VO_2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds. REJECTED.

3. There is no significant interaction of training groups and time on VO_2max, average HR, peak HR, RPE, PAE, BMI, waist circumference, and skinfolds. REJECTED.

Discussion

Previous researchers have suggested that the effects of various HIIT protocols, the differences between continuous aerobic exercise and HIIT, and the enjoyment of HIIT by adolescents should be examined (Logan et al., 2014). Because of the intensity of the activity during floorball and the rest periods utilized, floorball could be considered a HIIT protocol. The current study investigated the use of floorball as a HIIT protocol and compared it to SSE to examine the effects on cardiovascular fitness and body composition among adolescents and young adults. Also, the enjoyment of exercise was measured. The main finding of this study was that there was a significant increase of VO_2max in the floorball group whereas SSE group had no change in VO_2max.

There have been very few studies conducted related to floorball. Nyberg et al. (2014) found significant improvement in VO_2max after 12 weeks of playing floorball twice a week for 30 min. It was 4.6 ± 1.8% higher with premenopausal women and 5.5 ± 1.6% higher with postmenopausal women after the exercise program. The participants in this study were between the ages of 48 and 51 years. Seidelin et al. (2017) conducted a 12-week study with 52-year-old women where the participants played floorball twice a week for 30 min. Maximal oxygen uptake increased by 4.4 ± 1.5% with postmenopausal and 5.1 ± 2.4% with premenopausal women. Vorup et al. (2017) did not find a significant increase in VO_2max with 65-76-year-old men playing floorball twice a week for 12 weeks. None of these studies used a control group. The finding in the current study were similar findings to that of Nyberg et al. (2014) and Seidelin et al. (2017). At the end of the 7 weeks, maximal oxygen uptake increased by 4.4% in the group that played floorball twice a week for 20 min. The lack of accordance between the present study and the study by Vorup et al. (2017) could be due to the age of the participants. Aging has resulted in a decline in endurance performance and VO_2max. This is due to a decline in maximal cardiac output as well as a decrease in maximal arteriovenous oxygen difference (Powers & Howley, 2015; Tanaka & Seals, 2008).

It has been previously demonstrated that HIIT can lead to greater improvements in VO_2max compared to SSE. The findings of the present study are similar to that of Helgerud et al. (2007) and Vella et al. (2017). Helgerud et al. (2007) studied 40 healthy male participants. They were moderately active and had a mean age of 24.6 ± 3.8 years. The training was done three times a week for 8 weeks, and the HIIT and SSE protocols led to similar total oxygen consumption. High-intensity interval training significantly increased VO_2max compared to SSE (6.4 vs. 2.0%). This is similar to that observed by Vella et al. (2017) who studied 17 overweight and obese adults. That study lasted 8 weeks and the participants completed 30 min of exercise four times a week. Vella et al. (2017) found a 7.5% increase in VO_2max in HIIT group, but the SSE group did not improve. In the present study, the FRBL group significantly improved VO_2max by 4.4% whereas the SSE group did not significantly change. It is unclear why there was no change in VO_2max in the SSE group, but perhaps it was the result of the frequency of the exercise sessions. Other studies that have used SSE and found increases in VO_2max (Foster et al., 2015; Gillen et al., 2016), had frequencies of 3-4 times/week whereas the frequency in the current study was only 2 times/week. So perhaps a frequency greater than 2 times/week is needed with SSE. The reason a significant increase in VO_2max was found for the FRBL group but not the SSE group in the present study was possibly a result of the significantly higher peak HR during exercise in the FRBL group.

Other studies have shown even greater increases in VO_2max with HIIT compared to SSE (Hoydal & Hareide, 2016; Nybo et al., 2010). Hoydal & Hareide (2016) observed 11.3 ± 4.1% increase in VO_2max and Nybo et al. (2010) found 14 ± 2% improvement in VO_2max. There are, however, studies that did not note a significant difference in VO_2max between HIIT and SSE. For example, Foster et al. (2015) found that VO_2max increased significantly in both groups (18.5 ± 2.3%, on average) and there were no significant differences between the groups. The HIIT protocol lasted 14 min compared to the SSE protocol which lasted 30 min. These results are in line with the study conducted by Gillen et al. (2016) who found that both the HIIT and SSE groups increased their VO_2max by 19%. The discrepancy between these two studies and the current study might be due to the frequency, duration, intensity and mode of exercise. The above mentioned studies used a frequency of three days per week and shorter, more intense work intervals.

Following short duration training (i.e., ~ 4 months), improvements in VO_2max are most likely due to increases in maximal cardiac output (Cox, Bennett, & Dudley, 1986; Coyle et al., 1984; Powers & Howley, 2015). As training does not increase maximal heart rate, an increased SV is the most reasonable explanation for the increase in VO_2max. High-intensity interval training allows a person to complete short work periods at higher intensities. This type of training challenges the heart's pumping ability (i.e., SV) more than what would be possible with continuous, lower intensity exercise (Tjonna et al., 2009). For example, Tjonna et al. (2009) observed that maximal SV during exercise increased more after 3 months of HIIT, contributing to a greater increase in

VO_2max in the HIIT group compared to the SSE group. Montero, Díaz-Canestro, and Lundby (2015) state that in healthy, untrained individuals, the training induced improvements in VO_2max that occur following 1 to 4 months of training are due to maximal SV and are not related to arteriovenous oxygen difference. They also indicate that the increased VO_2max following longer duration training lasting 32 months or more is a result of increased SV as well as increased arteriovenous oxygen difference. Therefore, it can be speculated that the increased VO_2max observed with FRBL group in this study was due to an increased SV.

Other physiological changes taking place as a result of HIIT include an increased skeletal muscle oxidative capacity as reflected by the maximal activity or protein content of mitochondrial enzymes (Gibala, Little, Macdonald, & Hawley, 2012). For example, Burgomaster, Hughes, Heigenhauser, Bradwell, and Gibala (2005) reported 38% increase in maximal citrate synthase activity after 2 weeks (three sessions/week) of HIIT. Mitochondrial volume in muscle fibers is also increased as a result of HIIT (Gibala et al., 2006). Either of these are also possible reasons for the increase in VO_2max in the FRBL group but given the higher peak HR across all 7 weeks for the FRBL group, an increased SV seems a more likely explanation.

No significant differences in body composition measures were observed in this study. Agreement with results from previous studies are mixed (Buchan et al., 2011; Nyberg et al., 2014; Seidelin et al., 2017; Hazell et al., 2014; Knoepfli-Lenzin et al., 2010; Tjonna et al., 2009; Vorup et al., 2017). Buchan et al. (2011) recruited 47 boys and 10 girls (16.4 ± 0.7 years) to a 7-week study. Baseline percentage body fat was 19.2 ±

8.2%. Participants in the high-intensity group completed 30 s maximal sprints separated by 20-30 s rest. This protocol was repeated 4-6 times. Participants in the moderate intensity group ran at 70% VO_2max for 20 min. There was no significant difference in BMI, waist-to-hip ratio, or percentage body fat between the two exercise groups. Some possible reasons for the contradiction between the present study and the studies by Vorup et al. (2017), Knoepfli-Lenzin et al. (2010), Hazell et al. (2014), and Tjonna et al. (2009), who found significant differences in body fat percentage or fat mass, might be the duration of the study, the type of protocol used, and the participant characteristics. For example, Vorup et al. (2017) and Knoepfli-Lenzin et al. (2010) studies lasted 12 weeks, Hazell et al. (2014) controlled the total energy intake, and Tjonna et al. (2009) used participants who were obese.

Kessler, Sisson, and Short (2012) state that at least 12 weeks of HIIT is needed to see notable decreases in body weight and percent body fat. Therefore, the duration of the study might explain the discrepancy between the current study and the studies by Vorup et al. (2017) and Knoepfli-Lenzin et al. (2010). According to Swift et al. (2014), studies lasting 4 to 6 months show a maximum of 2 kg weight loss when exercise alone, lasting 150 min per week, is used in a weight loss program.

In the study by Hazell et al. (2014), there were no pre-to post-training differences in total energy intake. In the current study, energy intake was not controlled. This might have been a possible reason why Hazell et al. (2014) found significant differences in body fat mass after HIIT program and the current study did not.

Tjonna et al. (2009) used obese participants who had an average BMI of 33.2 ± 6.1 kg/m^2. In this study, the average BMI in the FRBL group was 25.2 ± 3.9 kg/m^2. This is most likely the reason for the discrepancy between the two studies. The amount of weight someone loses, especially at the beginning of a weight loss program, is proportional to the person's body weight. The person with more body weight burns more calories during the exercise session, and therefore he or she most likely will lose more weight.

It is also important to note that most of the participants in the present study were college freshmen, which may have affected the body composition results. Although participants were instructed to maintain their usual diet, students typically gain a significant amount of weight during the first semester of college (Wengreen & Moncur, 2009). This weight gain is related to unhealthy behaviors among college students, including decreased physical activity, increased rates of alcohol consumption, and decreased overall diet quality (de Vos et al., 2015). In the present study, a slight increase in all the body composition measures were observed, although the increases were not significant.

Gutin, Yin, Humphries, and Barbeau (2005) state that when training volumes are equal between those who perform HIIT and SSE separately, HIIT appears to be the best method to reduce weight. Not only is the total energy expenditure greater when the exercise intensity is high, but also the amount of fat metabolized is larger per unit of time (Bahr & Sejersted, 1991). Following HIIT, postexercise oxidation appears to be mainly supplied by fat during the first hours of recovery (Medbo & Jebens, 2002).

Obesity and cardiovascular fitness variables are strong and independent predictive markers of cardiovascular mortality. However, the link between cardiovascular fitness and mortality appears to be more compelling (Tjonna et al., 2009). According to Blair (2009), the Aerobics Center Longitudinal Study showed that low cardiovascular fitness accounted for about 16% of all deaths in the large population that they studied, and this was higher than any other risk factor for cardiovascular disease. Low cardiovascular fitness values for men and women between the ages of 40 and 60 are 5-9 METs (Lee, Artero, Sui, & Blair, 2010). Improving cardiovascular fitness can reduce the risk of mortality, regardless of the level of obesity. However, the highest risk of mortality is noted with individuals who have low cardiovascular fitness and who are obese in those who are both obese and unfit (Lee, Artero, Sui, & Blair, 2010). When interacting with overweight and obese clients, the emphasis should include improving cardiovascular fitness rather than simply focusing on weight loss. Tjonna et al. (2009) noted that HIIT partly or fully reversed several of the cardiovascular risk factors such as fat percentage, BMI, and VO_2max suggesting that HIIT might be a beneficial treatment strategy for overweight and obese individuals. The present study included participants who were overweight on average. The participants who were following the floorball protocol significantly improved their cardiovascular fitness although there was no change in body weight or percent body fat.

It is important to consider exercise enjoyment when trying to increase physical activity. Vella et al. (2017) completed a study with 17 overweight and obese adults. The study lasted 8 weeks and included both HIIT and SSE groups. Participants completed 30 min of exercise four times a week. There was no difference related to enjoyment between the HIIT and SSE groups (PACES of 100.1 vs. 100.3, respectively). These findings are consistent with that of the current study, as significant changes were not observed between the groups. One possible reason for this might have been the skill level of the FRBL group. Most of them had no previous experience in floorball and were sometimes frustrated about the lack of skill. Some participants even expressed a desire to be part of the SSE group. Also, half of the FRBL group met early in the morning, and it was noted that some of the participants did not come to the exercise sessions well rested, and therefore did not give their full effort. Although the game of floorball is easy to learn, it takes time to become acquainted with the rules and rate of play. The participants may have benefited from practice drills and instructions of the fundamental skills of floorball before the study began.

There is though evidence that HIIT is more enjoyable than SSE (Bartlett et al., 2011; Thum et al., 2017; Wisloff et al., 2007). Thum et al. (2017) examined the differences in enjoyment between SSE and HIIT. The participants were 12 recreationally active men and women with an average age of 29.5 ± 10.7 years. They completed two cycling sessions separated by 2 to 7 days. High-intensity interval training consisted of eight, 1 min trials at 85% maximal workload with 1 min of cycling at 25% of maximal workload between trials. Steady state exercise included cycling 20 min at 45% of maximal workload. The differences in enjoyment was investigated using the PACES and it showed that the participants enjoyed HIIT more (103.8 ± 9.4) compared to SSE (84.2 ± 19.1). Wisloff et al. (2007) recruited 27 patients with stable post-infarction heart failure.

The HIIT consisted of walking on a treadmill. The grade of the treadmill was adjusted so that the participants achieved 90% to 95% of peak HR. There were four work intervals that lasted 4 min each and they were separated by 3-min walking intervals at 50% to 70% of peak HR. The patients indicated that HIIT was more motivating because of the varied procedure and SSE was “quite boring.” Bartlett et al., (2011) investigated the effects of HIIT and SSE on eight recreational active men, and found greater enjoyment with HIIT. The HIIT consisted of six, 3-min running intervals at 90% of VO_2max separated by six, 3-min recovery periods at 50% of VO_2max

The HR response to HIIT is dependent on the protocol used. Weinstein, Bediz, Dotan, and Falk (1998) recorded peak heart rates of 170 bpm right after HIIT. Trapp, Chisholm and Boutcher (2007) found averages around 150 bpm after 5 min of HIIT and the HR increased to 170 bpm after 15 min of HIIT. Finally, Bracken, Linnane, and Brooks (2009) found heart rates between 142 bpm and 173 bpm following high intensity exercise. The sprint and recovery periods in these studies varied from 6 s to 4 min, and the participants were instructed to exercise as hard as they could. In the current study, the peak HR recorded during the 2 min of floorball was 189 ± 7 bpm, and the average HR was 159 ± 11 bpm. Peak HR was higher than in the study completed by Weinstein et al. (1998) and the average HR was similar to the studies mentioned above. Using floorball as a type of HIIT protocol does not allow for control of the intensity of exercise as well as in more traditional protocols that use treadmill or cycle ergometers. Still given the value of peak HR achieved, floorball might be an acceptable substitute for more traditional HIIT protocols.

This study has demonstrated that floorball is an efficient means of improving cardiovascular fitness with overweight adolescents. Although the exercise-session time for both groups was 30 min, during the sessions, the FRBL group exercised a total of 280 min during the 7-week study. That was about 35% less cumulative time than the SSE group, who exercised a total of 420 min. The results of this study may be useful for teachers and other professionals who work with adolescents. Given the constraints of school curricula, incorporating floorball into the Physical Education curriculum may help to increase the fitness level of adolescents with less total volume of exercise.

A possible limitation of this study was that the outside physical activity level of the participants was not measured. Participants were reminded weekly to not change their physical activity levels. Fitness levels (as measured by VO_2max) were the same between the FRBL and SEE groups at the start of the study so it seems likely their physical activity levels were the same at that point. Still, it could be argued that during the course of the study, participants in the FRBL group increased their outside physical activity levels to a greater degree and perhaps that accounted for the difference in changes in VO_2max. However, it seems doubtful that one group would increase their outside physical activity level more than the other. Thus, the more reasonable explanation for the increased VO_2max in the FRBL group was the consistently higher peak HR over the duration of the study. Nevertheless, accelerometers or other activity trackers could have been used to measure physical activity participants completed on their own and remains a limitation of this study.

Another limitation was that dietary intake was not controlled or assessed. Trying to control diet for 7 weeks in college students was beyond the scope of this study. Dietary intake could have been assessed pre and post, but given the unreliability (ICC = 0.35; Foster et al., 2019) and logistical issues of dietary recalls, no attempt was made to assess dietary intake. Participants were instructed to maintain their usual diet. It is possible there were increases in energy intake over the course of the study, but as the pre and post values for BMI, percent body fat, and waist circumference were very similar, it is unlikely there were any drastic changes in dietary intake that would have influenced the results of this study.

Finally, the skill level of participants can also be considered a limitation. Since most of the participants had no previous experience in floorball, it is possible they were not able to give their full effort during the game play. Their focus may have been more on the skill they were trying to execute rather than giving their full effort. Some participants had a difficult time holding the stick properly and demonstrating the proper way of passing and shooting the ball during the game play. However, even after playing floorball for several weeks, there were no changes in average or peak HR, so skill level does not seem to have impacted effort in any meaningful way. Other possible reasons for the participants not giving their full effort might have included fitness status, stress levels, lack of sleep, and time of day.

Conclusion

Within the limitations of this study, it can be concluded that use of floorball as a HIIT protocol is feasible and can result in improvements in VO_2max in overweight adolescents and young adults. However, floorball may not elicit any changes in body composition without a greater frequency of play as well as changes in dietary intake.

Recommendations for Further Studies

More studies should be conducted to compare the physiological effects of high-intensity team sports such as floorball with typical HIIT protocols. Team sports might be a great way for overweight and obese individuals to lose weight if they have basic skills in that particular sport. A person playing a team sport is more engaged in that activity compared to typical SSE and is not necessarily focused on the intensity of exercise as much. Participants might be having more fun than during typical HIIT and therefore would be more motivated and more likely to continue being physically active. However, this is only speculation, and future studies should investigate this further.

Long-term HIIT studies of at least 6 months are also needed (Campbell et al., 2019). Most of the HIIT studies conducted have lasted less than 12 weeks. This is likely inadequate time to observe changes in some physiological outcomes and the adherence to the HIIT program.

This is a first study done about the effects of floorball on adolescents. Tervo and Nordstrom (2014) noted that there has been no research conducted related to children or adolescents playing floorball, and there is a lack of scientific knowledge related to floorball in general. Therefore, more studies are needed, as the popularity of floorball is increasing in the US as well as around the world.

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APPENDIX A

Institutional Review Board Letter of Approval

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
https://www.twu.edu/institutional-review-board-irb/

DATE: July 13, 2018

TO: Mr. Vesa Naukkarinen
Kinesiology

FROM: Institutional Review Board (IRB) - Denton

Re: Approval for The Effects of Floorball on Cardiovascular Fitness and Body Composition of Adolescents (Protocol #: 20160)

The above referenced study was reviewed at a fully convened meeting of the Denton IRB (operating under FWA00000178). The study was approved on 7/13/2018. This approval is valid for one year and expires on 7/13/2019. The IRB will send an email notification 45 days prior to the expiration date with instructions to extend or close the study. It is your responsibility to request an extension for the study if it is not yet complete, to close the protocol file when the study is complete, and to make certain that the study is not conducted beyond the expiration date.

If applicable, agency approval letters must be submitted to the IRB upon receipt prior to any data collection at that agency. Please use the consent form with the most recent approval date stamp when obtaining consent from your participants. A copy of the signed consent forms must be submitted with the request to close the study file at the completion of the study.

Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All forms are located on the IRB website. If you have any questions, please contact the TWU IRB.

cc. Dr. George King, Kinesiology
Dr. David Nichols, Kinesiology
Graduate School

APPENDIX B

Informed Consent

TEXAS WOMAN'S UNIVERSITY
SOUTHWESTERN ADVENTIST UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Title: The Effects of Floorball on Cardiovascular Fitness and Body Composition of Adolescents

Investigator: Vesa Naukkarinen, MS.................................vnaukkar@swau.edu 817/202-6684
Advisor: David Nichols, PhD.................................DNichols@mail.twu.edu 940/898-2522

Explanation and Purpose of the Research

You are being asked to participate in a research study for Mr. Naukkarinen at Southwestern Adventist University (SWAU). The purpose of the study is to compare cardiovascular fitness and body composition measures before and after 7 weeks of high intensity interval training (HIIT) versus steady state exercise (SSE) in healthy adolescents.

Description of Procedures

If you agree to participate in this study, we will ask you to make two visits to the physical assessment laboratory at SWAU. During the visits, you will fill out a medical history questionnaire and you will have measurements taken of your height, weight, BMI, percent body fat, and resting heart rate. Resting heart rate will be assessed by having you lie down for 5 minutes in a relaxed state. You will be fitted with a heart rate monitor in order to precisely obtain beat-to-beat measurements. You will also be asked to perform a maximal graded exercise test on a treadmill. A mouthpiece with a one-way breathing valve attached to a breathing tube will be used to collect air samples during the exercise test. Essentially, subjects breathe room air through a mouthpiece, and then expire their air into a tube that connects to a machine. This machine analyzes carbon dioxide and oxygen content, which allows the researchers to calculate the amount of oxygen used by the subject under resting and exercise conditions. Your test protocol will involve a starting treadmill speed of 4 mph with 3% grade; the speed will be increased by 1 mph every 2 minutes until you reach a level of maximal exertion. You are free to discontinue the test at any time for any reason. You will be monitored by study personnel for the entirety of the test. You will be monitored following the test and you will be allowed to leave once your heart rate and blood pressure have returned to normal post-exercise levels. For the 12 hours preceding each visit, we ask that you: 1) not consume any food or drink that contains caffeine or other stimulants and 2) refrain from moderate or vigorous exercise or physical activity.

You will be asked to play floorball or walk/run on a treadmill for 30 minutes twice a week for seven weeks. Heart rates, physical effort, and perceived enjoyment of exercise will be collected during the exercise sessions. Heart rate will be measured using the heart rate monitor and physical effort and perceived enjoyment of exercise will be measured using a grading scale.

Potential Risks

There are risks and discomforts associated with the experiment. Certain changes in body function take place when any person exercises. Some of these changes are normal and others are abnormal. Abnormal changes may occur in blood pressure. A very rapid or very low heart rate may occur. Exercise carries a small risk of musculoskeletal injury, heart attack and, in rare instances, even death. Every effort will be made to minimize possible problems by the preliminary examination and constant surveillance during testing. Equipment and trained personnel are available to deal with unusual situations should they arise. In the event of an injury, first aid will be provided. In case of emergency, 911 will be called since SWAU does not have a medical center.

Approved by the
Texas Woman's University
Institutional Review Board
Approved: July 13, 2018

_______ Initials
Page 1 of 2

The researchers will try to prevent any problem that could happen because of this research. You should let the researchers know at once if there is a problem and they will help you. However, SWAU/TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research.

Participation and Benefits

Your involvement in this study is completely voluntary and you may withdraw from the study at any time. Following the completion of the study you will receive a $10 gift card for your participation. If you would like to know the results of this study we will mail them to you.* The confidentiality of those involved in the observation will be carried out, keeping their anonymity and privacy secure.

Questions Regarding the Study

You will be given a copy of this signed and dated consent form to keep. If you have any questions about the research study you should ask the researchers; their phone numbers are at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

______________________________ ____________
Signature of Participant Date

______________________________ ____________
Signature of a parent or legal guardian if under 18 Date

______________________________ ____________
Signature of Witness Date

"I have reviewed the contents of this form with the person(s) signing above. I have explained potential risks and benefits of the study."

______________________________ ____________
Signature of Investigator Date

*If you would like to know the results of this study tell us where you want them to be sent:

Email: ______________________
or
Address:
____
____

Approved by the
Texas Woman's University
Institutional Review Board
Approved: July 13, 2018

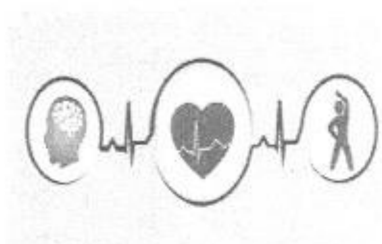
APPENDIX C

Participant Recruitment Material

VOLUNTEERS NEEDED FOR RESEARCH STUDY

WHO:

- Healthy male or female, 17 - 23 years old
- Body mass index (BMI) 20 - 35 kg/m^2
- Non-smoking
- Not participating in any organized sports



STUDY OBJECTIVE:

To compare cardiovascular fitness and body composition measures before and after 7 weeks of high-intensity interval training (HIIT) versus steady state exercise (SSE) in healthy adolescents.

INTERVENTION:

- You will be assigned to either a HIIT or SSE group. HIIT group will play intermittent stop-and-go sport and SSE will exercise on a treadmill. Both groups will meet twice a week for 30 minutes.
- Two visits to the laboratory to measure maximal oxygen consumption and body composition.
- Time commitment for the study is about 7 hours over a period of 7 weeks.

BENEFITS:

- ***Free maximal oxygen consumption analysis using state-of-the-art equipment (up to $250 value)***
- ***Free body composition analysis (up to $60 value)***
- ***Increased health and fitness level***
- ***Contribute to an increased understanding about the body's response to physical activity***
- ***Compensation of $20***

Confidentiality Statement: *There is a potential risk of loss of confidentiality in all email, downloading, and internet transactions. This study is voluntary and you may discontinue at any time.*

If you are eligible and interested, please contact: *Vesa Naukkarinen at (817)202-6684 or vnaukkar@swau.edu*

APPENDIX D

Physical Activity Readiness Questionnaire+ (PAR-Q+)

2018 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it ***does not limit your current ability*** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness centre may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______________________ DATE ______________

SIGNATURE ______________________ WITNESS ______________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

01-11-2017

APPENDIX E

Raw Data

Participant	Group (1=SSE; 2=HIIT)	Gender (1=male; 2=female)	Age (y)	Height (cm)	Weight_pre (kg)	Weight_post (kg)
1	1.00	2.00	19	163.0	74.5	76.4
2	1.00	1.00	19	188.0	85.0	86.8
3	1.00	2.00	18	163.0	61.4	61.8
4	1.00	1.00	19	175.0	86.8	84.5
5	1.00	2.00	18	165.0	73.2	74.5
6	1.00	2.00	19	160.0	72.7	73.6
7	1.00	1.00	18	185.0	96.4	99.1
8	1.00	1.00	18	183.5	95.5	91.8
9	1.00	2.00	19	162.5	60.5	60.5
10	1.00	2.00	19	157.0	59.5	63.2
11	1.00	1.00	18	171.5	76.4	77.7
12	1.00	1.00	19	172.0	75.0	74.5
13	1.00	2.00	18	161.0	52.3	54.1
14	1.00	1.00	19	167.0	63.6	61.8
15	1.00	1.00	19	175.5	92.7	93.2
16	1.00	2.00	17	155.0	63.6	62.7
17	1.00	1.00	19	175.0	93.6	95.0
18	2.00	1.00	23	181.0	101.4	99.5
19	2.00	2.00	20	174.0	62.3	62.3
20	2.00	2.00	18	165.0	95.0	93.6
21	2.00	1.00	19	169.0	65.9	66.8
22	2.00	2.00	18	168.0	74.1	80.9
23	2.00	2.00	18	169.0	65.9	68.2
24	2.00	1.00	21	169.5	74.5	75.5
25	2.00	1.00	18	163.5	72.3	74.1
26	2.00	1.00	22	185.0	83.2	84.5
27	2.00	2.00	22	151.0	57.7	58.6
28	2.00	1.00	20	176.0	79.1	81.1
29	2.00	2.00	18	154.5	75.9	72.7
30	2.00	2.00	20	163.0	55.5	53.6
31	2.00	2.00	19	158.0	57.3	58.6
32	2.00	1.00	21	174.0	68.2	67.7
33	2.00	1.00	17	178.5	84.5	86.8

Participant	Skinfoldsum_pre (cm)	Skinfoldsum_post (cm)	Bodyfat_pre (%)	Bodyfat_post (%)	Waist_pre (cm)	Waist_post (cm)
1	76.5	81.0	28.5	29.8	82.5	85.0
2	51.5	53.5	14.3	14.9	80.0	82.0
3	63.0	65.5	24.3	25.1	69.0	69.0
4	71.0	69.0	19.7	19.2	90.0	87.0
5	91.5	92.0	32.7	32.8	80.0	80.0
6	100.0	103.5	35.0	35.8	79.0	79.0
7	87.0	89.0	23.7	24.2	98.5	99.0
8	103.5	100.0	27.7	26.8	91.5	89.0
9	58.0	59.0	22.7	23.1	70.0	72.0
10	78.0	82.0	28.9	30.1	80.0	81.5
11	44.0	47.5	12.0	13.0	79.0	81.0
12	73.5	73.0	20.4	20.2	82.0	81.0
13	45.0	43.0	18.3	17.6	63.0	62.0
14	67.5	64.0	18.8	17.8	76.0	74.5
15	82.0	83.0	22.6	22.8	91.0	92.5
16	76.0	75.0	28.2	27.9	75.0	74.0
17	112.5	114.0	29.8	30.1	101.0	101.5
18	153.0	146.5	38.0	36.9	101.0	100.0
19	75.5	75.0	28.3	28.1	76.0	75.0
20	103.5	100.0	35.8	34.9	95.0	93.0
21	69.0	69.5	19.2	19.3	78.0	78.5
22	98.5	100.5	34.5	35.0	78.0	80.0
23	91.0	94.5	32.6	33.5	75.0	76.0
24	88.0	89.0	24.3	24.6	77.0	77.0
25	94.5	96.0	25.5	25.9	85.0	85.0
26	83.0	87.5	23.2	24.3	87.5	88.0
27	72.0	72.5	27.3	27.5	76.0	78.0
28	77.0	79.0	21.4	21.9	82.0	83.0
29	97.0	93.0	34.1	33.1	89.0	85.0
30	61.0	59.0	23.8	23.1	64.0	64.0
31	59.5	60.5	23.2	23.5	74.5	75.0
32	27.0	27.0	7.1	7.1	74.0	74.0
33	68.0	70.0	18.7	19.2	82.0	83.0

Participant	BMI_pre (kg/m^2)	BMI_post (kg/m^2)	VO2max_pre (ml/kg/min)	VO2max_post (ml/kg/min)
1	28.0	28.7	33.8	28.1
2	24.0	24.5	49.5	47.7
3	23.0	23.2	31.9	35.2
4	28.3	27.5	49.1	49.2
5	26.5	27.0	27.2	27.7
6	28.3	28.7	26.9	28.6
7	28.1	28.9	43.7	41.4
8	28.3	27.2	36.9	37.3
9	22.8	22.8	28.5	29.7
10	24.1	25.6	37.8	35.2
11	25.9	26.4	48.9	50.4
12	25.3	25.1	43.4	46.9
13	20.1	20.8	38.2	36.2
14	22.8	22.1	43.9	45.5
15	30.0	30.2	34.4	36.3
16	26.4	26.1	33.7	36.7
17	30.5	31.0	33.4	35.5
18	30.9	30.3	29.2	31.0
19	20.5	20.5	33.2	36.4
20	34.8	34.3	31.8	33.3
21	23.0	23.3	49.2	46.4
22	26.2	28.6		
23	23.0	23.8	26.6	29.7
24	25.9	26.2	44.2	48.6
25	27.0	27.7	41.6	45.1
26	24.3	24.6	34.5	38.3
27	25.3	25.7	32.7	35.7
28	25.5	26.1	46.4	44.3
29	31.7	30.4		
30	20.8	20.1	38.0	39.8
31	22.9	23.4	22.7	31.3
32	22.5	22.3	52.8	55.0
33	26.5	27.2	42.0	43.8

Participant	Group	HRave_wk1	HRpeak_wk1	RPE_wk1	PAE_wk1	HRave_wk2
1	1.00	154.00	163.00	17.00	89.00	156.00
2	1.00	169.00	187.00	16.00	95.00	
3	1.00	171.00	184.00	13.00	87.00	166.00
4	1.00	141.00	185.00	14.00	115.00	160.00
5	1.00	161.00	182.00	13.00	108.00	153.00
6	1.00	133.00	179.00	13.00	77.00	159.00
7	1.00	152.00	173.00	14.00	120.00	154.00
8	1.00	161.00	183.00	16.00	105.00	162.00
9	1.00	150.00	169.00	13.00	92.00	157.00
10	1.00	163.00	179.00	16.00	89.00	152.00
11	1.00	161.00	183.00	14.00	84.00	164.00
12	1.00	160.00	179.00	12.00	86.00	156.00
13	1.00	156.00	173.00	12.00	55.00	149.00
14	1.00	156.00	182.00	12.00	87.00	154.00
15	1.00	165.00	175.00	13.00	83.00	161.00
16	1.00	156.00	181.00	12.00	116.00	159.00
17	1.00	164.00	176.00	12.00		166.00
18	2.00	164.00	199.00	16.00	113.00	157.00
19	2.00	181.00	195.00	16.00	116.00	180.00
20	2.00	172.00	193.00	16.00	102.00	164.00
21	2.00	165.00	182.00	14.00	123.00	166.00
22	2.00	168.00	191.00	16.00	115.00	144.00
23	2.00	170.00	186.00	14.00	126.00	169.00
24	2.00	145.00	182.00	12.00	90.00	156.00
25	2.00	153.00	185.00	14.00	75.00	148.00
26	2.00	146.00	182.00	14.00	108.00	139.00
27	2.00	142.00	173.00	13.00	86.00	175.00
28	2.00	164.00	191.00	14.00	87.00	158.00
29	2.00	151.00	186.00	14.00	107.00	154.00
30	2.00	159.00	190.00	13.00	80.00	168.00
31	2.00	165.00	193.00	15.00	115.00	
32	2.00	132.00	171.00	14.00	94.00	
33	2.00	159.00	197.00	14.00		

Participant	Group	HRpeak_wk2	RPE_wk2	PAE_wk2	HRave_wk3	HRpeak_wk3	RPE_wk3
1	1.00	164.00	16.00	94.00	156.00	166.00	15.00
2	1.00			98.00	167.00	183.00	16.00
3	1.00	181.00	13.00	83.00	155.00	178.00	13.00
4	1.00	176.00	13.00	114.00	150.00	167.00	13.00
5	1.00	171.00	14.00	110.00	154.00	171.00	15.00
6	1.00	195.00	12.00	74.00	137.00	187.00	13.00
7	1.00	174.00	13.00	121.00	151.00	172.00	13.00
8	1.00	179.00	15.00	108.00	149.00	173.00	15.00
9	1.00	177.00	13.00	103.00	143.00	161.00	13.00
10	1.00	176.00	15.00	94.00	147.00	171.00	15.00
11	1.00	177.00	13.00	82.00	160.00	181.00	13.00
12	1.00	177.00	11.00	87.00	145.00	175.00	14.00
13	1.00	162.00	11.00	55.00	141.00	163.00	11.00
14	1.00	193.00	11.00	98.00	137.00	157.00	11.00
15	1.00	174.00	12.00	94.00	167.00	182.00	12.00
16	1.00	174.00	12.00	113.00	150.00	168.00	13.00
17	1.00	178.00	12.00	120.00	170.00	182.00	13.00
18	2.00	196.00	15.00	94.00	150.00	188.00	18.00
19	2.00	196.00	17.00	95.00	178.00	193.00	18.00
20	2.00	190.00	16.00	109.00	166.00	192.00	17.00
21	2.00	187.00	15.00	102.00	168.00	191.00	17.00
22	2.00	184.00	14.00	125.00	164.00	188.00	17.00
23	2.00	199.00	16.00	126.00	152.00	183.00	14.00
24	2.00	181.00	15.00		150.00	181.00	18.00
25	2.00	189.00	15.00	103.00	154.00	193.00	15.00
26	2.00	165.00	14.00	100.00	161.00	185.00	14.00
27	2.00	201.00	13.00	118.00	136.00	169.00	14.00
28	2.00	185.00	13.00	113.00	162.00	193.00	16.00
29	2.00	186.00	15.00	90.00	168.00	193.00	15.00
30	2.00	199.00	16.00	91.00	159.00	194.00	14.00
31	2.00			101.00	134.00	183.00	14.00
32	2.00			77.00	172.00	200.00	20.00
33	2.00						

Participant	Group	PAE_wk3	HRave_wk4	HRpeak_wk4	RPE_wk4	PAE_wk4	HRave_wk5
1	1.00	98.00	154.00	166.00	13.00	100.00	131.00
2	1.00	94.00	164.00	179.00	15.00	97.00	166.00
3	1.00	89.00	161.00	175.00	13.00	97.00	158.00
4	1.00	107.00	152.00	170.00	13.00	105.00	163.00
5	1.00	106.00	152.00	174.00	13.00	99.00	158.00
6	1.00	73.00	130.00	171.00	13.00	110.00	146.00
7	1.00	107.00	143.00	178.00	14.00	112.00	144.00
8	1.00	111.00	154.00	169.00	16.00	106.00	153.00
9	1.00	105.00	151.00	169.00	11.00	109.00	149.00
10	1.00	94.00	148.00	170.00	16.00	86.00	142.00
11	1.00	82.00	161.00	180.00	13.00	94.00	164.00
12	1.00	84.00	150.00	178.00	13.00	108.00	156.00
13	1.00	66.00	149.00	180.00	12.00	80.00	151.00
14	1.00	114.00	159.00	178.00	11.00	100.00	159.00
15	1.00	88.00	166.00	183.00	12.00	97.00	165.00
16	1.00		158.00	176.00	13.00		152.00
17	1.00		171.00	188.00	12.00		168.00
18	2.00	124.00	167.00	203.00	19.00	93.00	154.00
19	2.00	114.00	178.00	196.00	19.00	126.00	179.00
20	2.00	75.00	168.00	190.00	17.00	126.00	164.00
21	2.00	108.00	152.00	179.00	17.00	83.00	161.00
22	2.00	100.00	167.00	195.00	15.00	109.00	157.00
23	2.00	117.00	156.00	177.00	17.00	126.00	156.00
24	2.00	126.00	158.00	194.00	15.00	126.00	154.00
25	2.00	102.00	160.00	184.00	18.00	76.00	152.00
26	2.00	102.00	154.00	191.00	16.00	114.00	162.00
27	2.00	98.00	175.00	200.00	16.00	102.00	159.00
28	2.00	114.00	161.00	191.00	15.00	100.00	173.00
29	2.00	112.00	149.00	191.00	15.00	105.00	158.00
30	2.00	90.00	147.00	180.00	17.00	83.00	174.00
31	2.00	94.00	162.00	195.00	17.00	90.00	
32	2.00	86.00				90.00	
33	2.00						

Participant	Group	HRpeak_wk5	RPE_wk5	PAE_wk5	HRave_wk6	HRpeak_wk6	RPE_wk6
1	1.00	160.00	13.00	103.00	150.00	165.00	14.00
2	1.00	180.00	15.00	116.00	162.00	177.00	15.00
3	1.00	172.00	13.00	106.00	159.00	175.00	13.00
4	1.00	178.00	13.00	120.00	161.00	178.00	13.00
5	1.00	175.00	13.00	119.00	147.00	168.00	13.00
6	1.00	192.00	12.00	101.00	162.00	196.00	13.00
7	1.00	169.00	13.00	89.00	153.00	168.00	15.00
8	1.00	177.00	16.00	96.00	161.00	180.00	15.00
9	1.00	172.00	13.00	91.00	152.00	175.00	11.00
10	1.00	170.00	14.00	87.00	157.00	178.00	16.00
11	1.00	180.00	13.00	98.00	168.00	184.00	13.00
12	1.00	179.00	11.00	100.00	153.00	177.00	12.00
13	1.00	165.00	11.00	101.00	155.00	183.00	10.00
14	1.00	169.00	11.00	110.00	154.00	163.00	11.00
15	1.00	178.00	12.00	98.00	158.00	174.00	13.00
16	1.00	174.00	13.00	92.00	151.00	169.00	12.00
17	1.00	180.00	11.00	97.00	164.00	176.00	12.00
18	2.00	193.00	18.00	101.00	154.00	196.00	18.00
19	2.00	195.00	17.00	102.00	175.00	194.00	18.00
20	2.00	193.00	16.00	103.00	162.00	190.00	16.00
21	2.00	180.00	16.00	79.00	166.00	185.00	18.00
22	2.00	186.00	15.00	126.00	148.00	181.00	15.00
23	2.00	186.00	16.00	126.00	161.00	192.00	15.00
24	2.00	179.00	17.00		153.00	184.00	17.00
25	2.00	190.00	15.00	114.00	153.00	185.00	14.00
26	2.00	189.00	16.00	103.00	155.00	188.00	16.00
27	2.00	187.00	17.00	97.00	145.00	168.00	17.00
28	2.00	199.00	15.00	97.00	154.00	185.00	16.00
29	2.00	190.00	17.00	102.00	157.00	185.00	16.00
30	2.00	198.00	18.00	94.00	159.00	189.00	18.00
31	2.00			105.00	169.00	195.00	18.00
32	2.00						
33	2.00						

Participant	Group	PAE_wk6	HRave_wk7	HRmax_wk7	RPE_wk7	PAE_wk7
1	1.00	99.00	154.00	170.00	13.00	107.00
2	1.00	123.00	160.00	172.00	16.00	104.00
3	1.00	109.00	159.00	172.00	13.00	106.00
4	1.00	108.00	160.00	178.00	13.00	122.00
5	1.00	119.00	153.00	164.00	12.00	116.00
6	1.00	116.00	151.00	196.00	13.00	101.00
7	1.00	91.00	133.00	156.00	14.00	104.00
8	1.00	107.00	160.00	176.00	15.00	87.00
9	1.00	104.00	155.00	168.00	14.00	92.00
10	1.00	81.00	156.00	178.00	14.00	104.00
11	1.00	97.00	156.00	179.00	13.00	107.00
12	1.00	95.00	153.00	174.00	13.00	97.00
13	1.00	96.00	149.00	164.00	10.00	81.00
14	1.00	102.00	148.00	165.00	11.00	92.00
15	1.00	85.00	134.00	174.00	12.00	102.00
16	1.00	77.00	146.00	174.00	14.00	106.00
17	1.00	76.00	169.00	181.00	12.00	
18	2.00	123.00	143.00	198.00	17.00	126.00
19	2.00	88.00	176.00	193.00	17.00	104.00
20	2.00	75.00	162.00	201.00	17.00	126.00
21	2.00	112.00	154.00	180.00	16.00	90.00
22	2.00	126.00	147.00	184.00	16.00	101.00
23	2.00	100.00	162.00	185.00	15.00	108.00
24	2.00	82.00	142.00	177.00	15.00	69.00
25	2.00	78.00	150.00	179.00	16.00	81.00
26	2.00	88.00	146.00	185.00	13.00	99.00
27	2.00	120.00	160.00	186.00	15.00	111.00
28	2.00	104.00	128.00	171.00	15.00	99.00
29	2.00	103.00	163.00	189.00	17.00	101.00
30	2.00	98.00	147.00	176.00	18.00	105.00
31	2.00	94.00	159.00	188.00	18.00	113.00
32	2.00					
33	2.00					